Miscellaneous Paper CERC-94-3
March 1994

US Army Corps
of Engineers
Waterways Experiment
Station



# Coastal Studies in Support of the Sargent Beach, Texas, Erosion Control Project

*by Donald K. Stauble, Jon M. Hubertz,*
*Robin J. Hoban, Claire R. Livingston, Cheryl E. Pollock*
*Coastal Engineering Research Center*

*Douglas R. Levin*
*Bryant College*



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Prepared for Headquarters, U.S. Army Corps of Engineers
and U.S. Army Engineer District, Galveston

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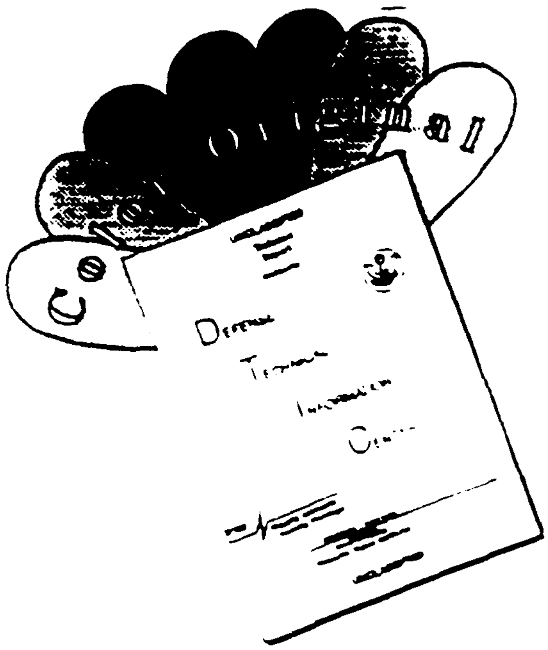

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Coastal Engineering Research Center

U.S. Army Corps of Engineers
Waterways Experiment Station
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

Douglas R. Levin

Science Department
Bryant College
Smithfield, RI 02917

Final report



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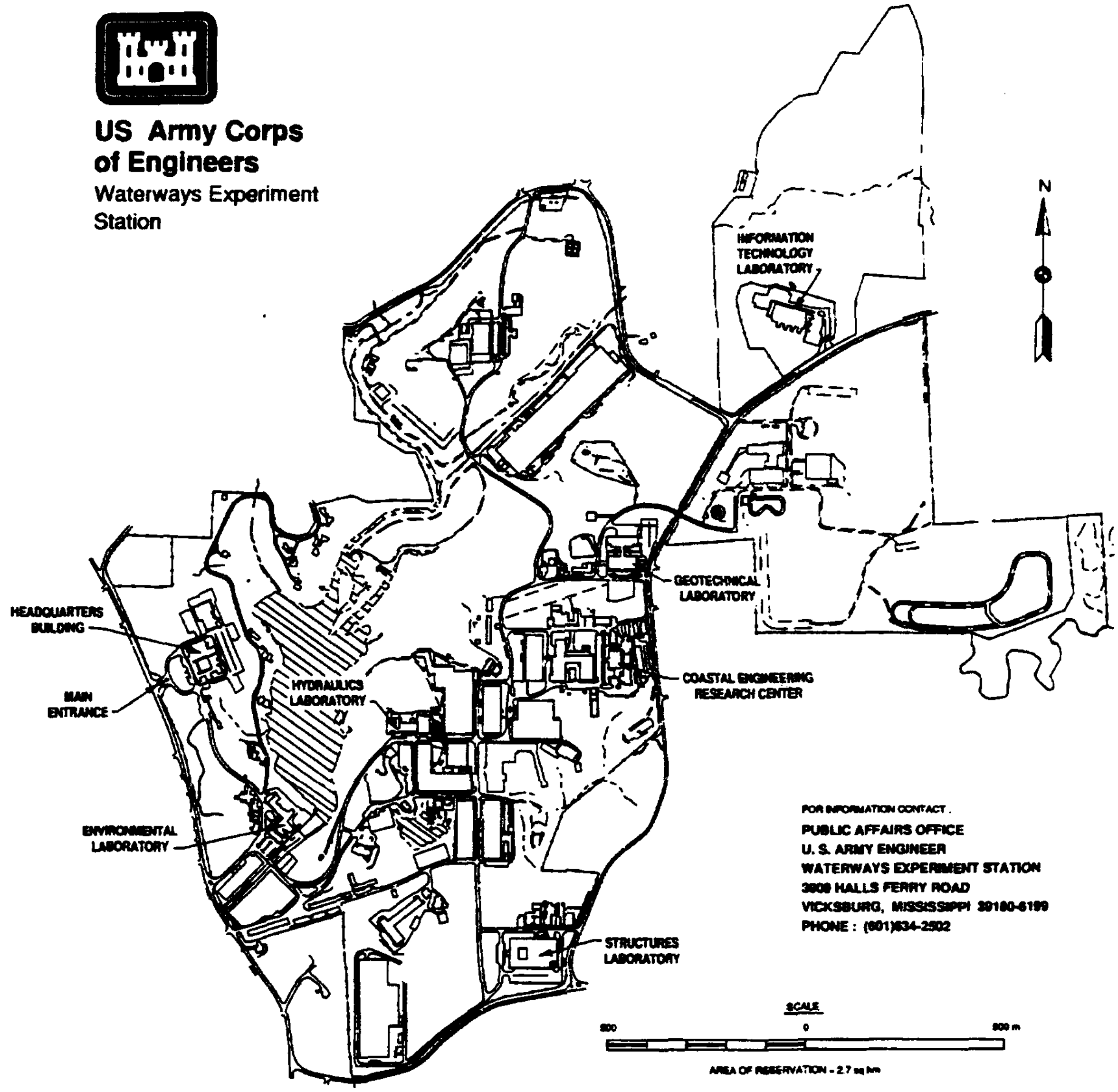
**US Army Corps of Engineers**
Waterways Experiment Station

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# Contents

# List of Figures

## List of Tables

# Preface

The investigation reported herein was requested by the U.S. Army Engineer District, Galveston (SWG). Funding authorization was initially granted by SWG on 19 Januuary 1990 as Military Inter-Departmental Purchase Request (MIPR) 90S006.

Studies were conducted at the U.S. Army,Engineer Waterways Experiment Station (WES) during the period January 1990 to December 1991 under the general direction of Dr. James R. Houston, Director, Coastal Engineering Research Center (CERC); Mr. Charles C. Calhoun, Jr., Assistant Director, CERC; Mr. Thomas Richardson, Chief, Engineering Development Division; Ms. Joan Pope, Chief, Coastal Structures and Evaluation Branch (CSEB); Dr. Yen-hsi Chu, Chief, Engineering Unit; and Ms. Cheryl E. Pollock, Principal Investigator. Studies were conducted by Drs. Donald K. Stauble and Jon M. Hubertz. Ms. Robin J. Hoban, Physical Science Technician, Coastal Oceanography Branch (COB), assisted in the research, planning and execution of the hurricane water level and wave height analyses, as well as final report computer graphics. Ms. Claire R. Livingston, Contract Student CSEB, assisted in coastline digitizing, zoom transfer analysis, core log descriptions, fine grained sediment analysis and compilation of grain-size and shoreline change data; Mr. David Stauts and Mr. Danny Marshall, Contract Students, CSEB, assisted in preparation of final report computer graphics; Mr. Corey Kindhart, Contract Student, CSEB, assisted in the coarse grain size distribution analysis; Ms. Karen Pitchford, Technician, CSEB, assisted in data reduction and analysis of shoreline statistics. The Mechanism of Erosion Study was conducted by Dr. Douglas R. Levin, under a contract with Bryant College Science Department.

At the time of publication of this report, Dr. Robert W. Whalin was Director of WES. COL Bruce K. Howard, EN, was Commander.

# Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

| Multiply | By | To Obtain |
|---|---|---|
| cubic yards | 0.7645549 | cubic meters |
| degrees (angle) | 0.1745329 | radians |
| feet | 0.3048 | meters |
| inches | 2.54 | centimeters |
| miles (U.S. statute) | 1.609347 | kilometers |
| miles (U.S. nautical) | 1.852 | kilometers |

# 1 Introduction

One of the areas of highest coastal erosion rates along the Texas coast is located in the deltaic headland coastal segment of the Brazos River in the vicinity of Sargent Beach. Sargent Beach is located south of Freeport, Texas, some 50 miles (80 km) southeast of Galveston (Figure 1)[1]. Because of this erosion, a section of the Gulf Intracoastal Waterway (GIWW) from Cedar Lakes to East Matagorda Bay is in danger of intrusion from breaching of the narrow (less than 1000 ft wide) shorefront. If measures are not taken in the immediate future, this reach of the GIWW will no longer be a viable route for barge transportation of commercial goods.

Owing to its deltaic origin, the beach is composed of cohesive fine grained clay and silt material, overlain by a narrow layer of coastal peat and topped by a thin veneer of fine-grained quartz beach sand with a high percentage of shell fragments. The northeastern half of the study area has an average erosion rate of 25 ft/yr and has a thin sandy flat sloping beach over the mud deposit. The southwestern section has up to a meter high clay bluffs outcropping into the surf zone and has an average 36 ft/yr erosion rate. It is speculated that this high erosion rate is a result of intermittent wave cutting of large chunks of the clay bluff material. The overall erosion rate along this coast is due to a general lack of sand.

The primary sediment source for this coast was the Colorado to Brazos River fluvial-delta complex encompassing from north to south Oyster Creek, Brazos River, the San Bernard River, Caney Creek and the Colorado River. Climatically reduced discharge and resulting drop in sediment yield has been proposed as the main cause to shift from progradation to erosion along this coast (Morton and Nummedal 1982). Flood control structures have also been built along these rivers in the recent past and are suspected to reduce inflow of new sediments from entering the nearshore system (Field, et al. 1990). Further, from this study and others (Wilkinson and Basse 1978; Weiss and Wilkinson 1988) it was found that there is a lack of sand-size material in the nearshore.

1 A table of factors for converting non-SI units of measurement to SI units is presented on page viii.

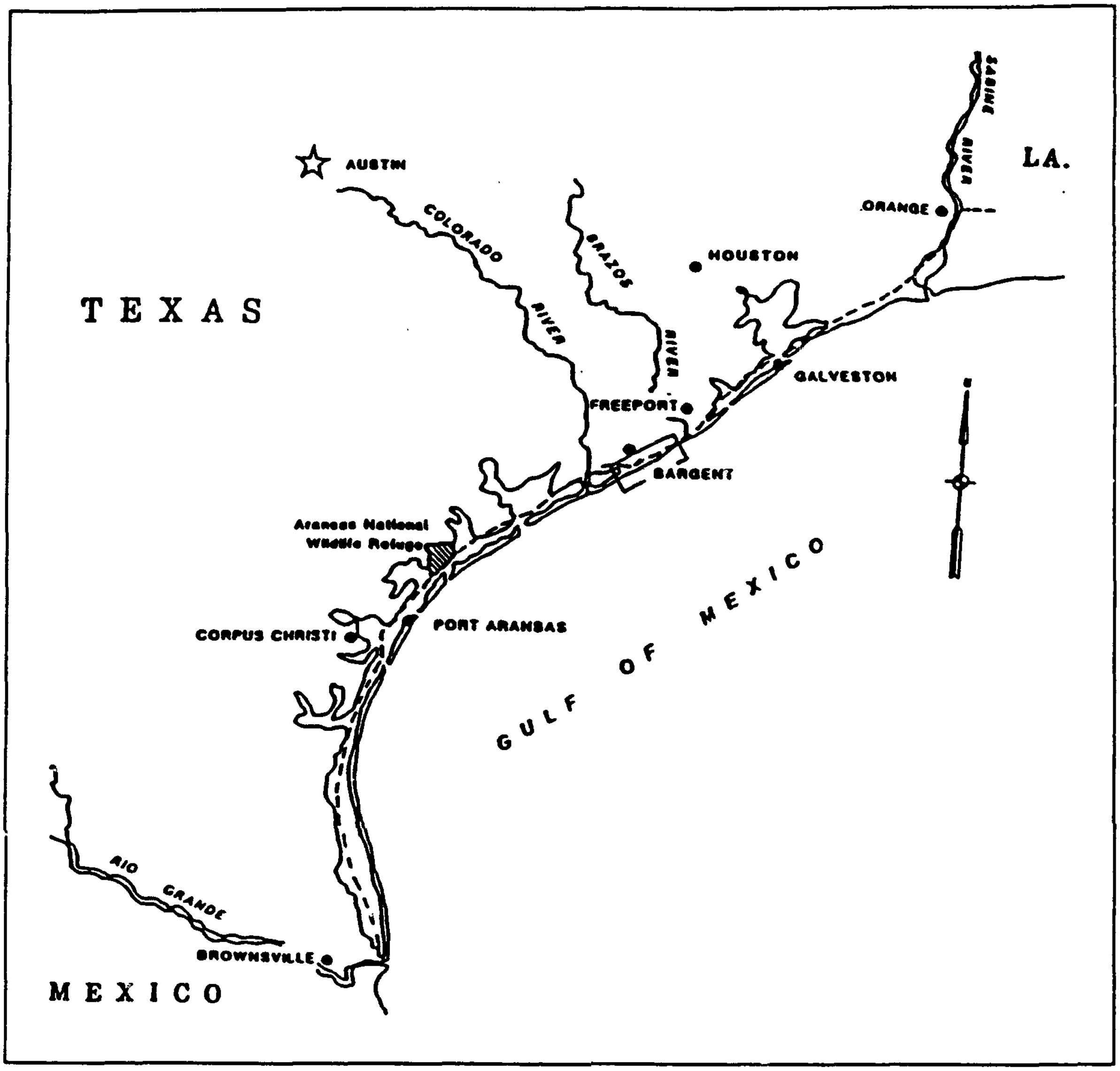



Figure 1. Location map of Sargent Beach

Since this coast has a high erosion rate that has resulted in narrowing the barrier island, a threat of breaching of the GIWW in the near future exists. This portion of the GIWW is an important link in waterborne commerce. The U.S. Army Engineer District, Galveston (SWG) has asked the Coastal Engineering Research Center (CERC) to provide studies pertaining to this erosion problem. CERC provided assistance in the development of a Study Plan for an evaluation of shoreline conditions and processes along the Sargent Beach and adjacent coastal elements. The primary objectives of this program are two-fold; (1) accurately determine the rate and mechanics of shoreline erosion in the Sargent Beach area and (2) provide process data to facilitate design and selection of the most feasible alternative solution that will protect the intracoastal waterway. Four topics of study were undertaken to evaluate the effects of a no action scenario which would support the need to provide structural or other protection and to provide the data necessary to design and evaluate a sound shore protection scheme. This report was divided into four parts covering:

*a*. The estimated water levels and wave heights that could be expected to occur at Sargent Beach and that would impact the shoreline erosion and provide guidance in erosion control structure design.

*b*. The historic shoreline changes and sediment distribution along the study area documenting the temporal erosion patterns and spatial sediment deposition patterns,

*c*. The mechanism of erosion of this cohesive shoreline.

*d*. The assessment of beach nourishment as an alternative erosion control method to protect the (GIWW) and provide a buffer zone to prevent breaching and degradation of the water way from the rapidly eroding coastline.

# 2 Estimated Hurricane Water Levels and Wave Heights for Sargent Beach, Texas

## Introduction

The Coastal Engineering Research Center (CERC) was contacted by the U.S. Army Engineer District, Galveston to provide assistance in designing an erosion control project at Sargent Beach, Texas. A multi-study plan was proposed by CERC and adopted by the District. The wave and water level studies were assigned to the Wave Information Study (WIS). This chapter reports on the results of those tasks.

The objective of water level study is to estimate, from available information, a stage frequency curve for the site due to hurricanes. This information will be used to help determine the crest elevation of the protective work. Note that the design is not expected to provide flood protection over the life of the project, but only to mitigate the rate of erosion at the site.

The objective of the wave study is to estimate, from available information, the wave conditions at the site under hurricane conditions and assign a return period to storms of various intensity. Hurricanes represent the design storms at the site. This wave information will be used to aid in the design of an erosion control project. For example, if a stone breakwater is chosen as the protective work, the wave information will help in determining the stone size needed for stability and survival of the project for a lifetime of approximately 50 years.

The approach in this study is to examine existing publications and other available information to determine the occurrence of hurricanes in this area, their intensity, and any indication of water level and wave heights near the project site. The historical frequency of occurrence of hurricanes is used to estimate a return period which is associated with water levels and wave heights.

There are not enough measurements or model results available to construct a probability of occurrence diagram for either water level or wave height. Such diagrams are usually the result of a joint probability method study involving the simulation of hundreds of synthetic storms. Such an approach is not practical for this study, at this time. As an alternative, return periods have been associated with storm category based on historical data. The storms occurring within 75 n.m. of the site have been assigned a category based on central atmospheric pressure and maximum sustained wind speed. The Saffir/ Simpson Scale, (Simpson and Riehl 1981), shown in Table 1 is used to assign the category for each storm. By considering the number of storms occurring over the period of record and their category, one can estimate a return period for each category, assuming storms of all categories occurred over the period of record. This type of approach, although not as detailed as a joint probability study, gives a first order estimate of return periods for various storm intensities.

**Table 1**
**Saffir/Simpson Hurricane Categories**

| | Central Pressure | | Wind Speed | | |
|---|---|---|---|---|---|
| Category | Millibars | Inches of Hg | MPH | Knots | Damage |
| 1 | >980 | >28.9 | 74-95 | 64-83 | Minimal |
| 2 | 965-979 | 28.5-28.9 | 96-110 | 84-96 | Moderate |
| 3 | 945-964 | 27.9-28.5 | 111-130 | 97-113 | Extensive |
| 4 | 920-944 | 27.2-27.9 | 131-155 | 144-135 | Extreme |
| 5 | <920 | <27.2 | >155 | >135 | Catastrophic |

# Historical Storms

A total of 24 storms were identified which passed within 75 n.m. of Sargent Beach, TX. These storms were selected using the National Hurricane Center (NHC) Risk Analysis Program (HURISK), a computerized model that accesses the extensive NHC database of historical tropical cyclone information (Neumann 1987). The storms occurred within the 104 year period from 1886 to 1990. An additional 9 storms occurred in the vicinity between 1871 and 1885, but track and category data are limited for these earlier years. Due to the lack of specific intensity information, these storms were not included in the population to determine return periods. The criteria for selection was that a storm had to be of hurricane intensity and pass within 75 n.m. of Sargent Beach. The site location was specified as 28.6 deg N and 95.9 deg W (center of circle in Figure 2), about 30 n.m. to the west of Sargent Beach, in order to favor storms on a critical path to Sargent Beach.

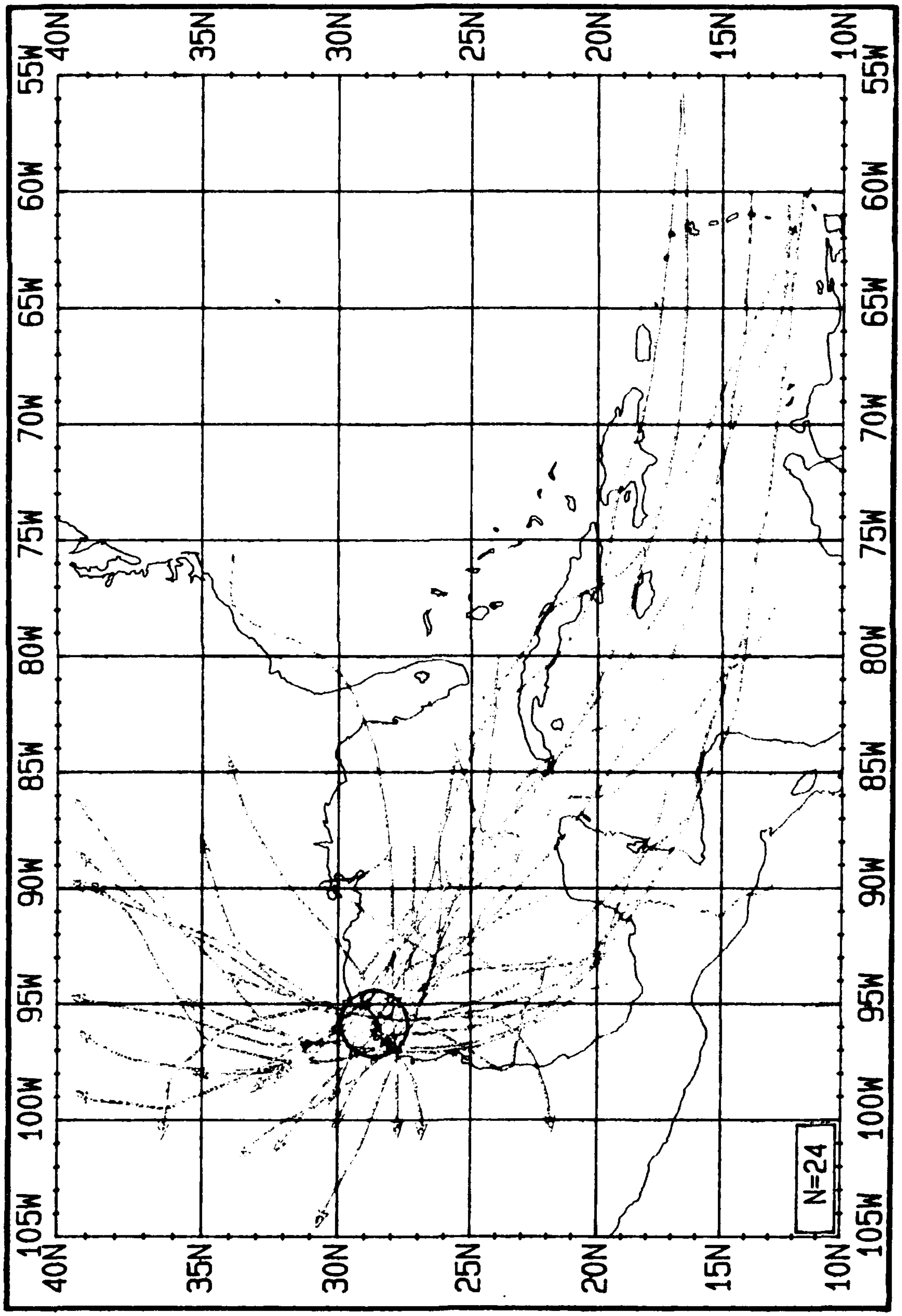



Figure 2. Tracks of hurricanes passing within 75 n.m. of Sargent Beach, TX: 1886-1990

The 24 storms meeting this criteria are summarized in Table 2. The date and category are at the time of closest approach. Prior to 1950 storms were not named.

**Table 2**
**Storms Passing Within 75 n.m. of Sargent Beach, TX (1886-1989)**

| Storm Name | Year | Month | Category |
|---|---|---|---|
| Not Named | 1886 | Aug | 2 |
| Not Named | 1888 | Jun | 1 |
| Not Named | 1891 | Jul | 1 |
| Not Named | 1900 | Sep | 3 |
| Not Named | 1902 | Jun | 1 |
| Not Named | 1909 | Jul | 1 |
| Not Named | 1915 | Aug | 1 |
| Not Named | 1921 | Jun | 1 |
| Not Named | 1929 | Jun | 1 |
| Not Named | 1932 | Aug | 1 |
| Not Named | 1934 | Jul | 1 |
| Not Named | 1934 | Aug | 1 |
| Not Named | 1941 | Sep | 1 |
| Not Named | 1942 | Aug | 1 |
| Not Named | 1945 | Aug | 4 |
| Not Named | 1947 | Aug | 1 |
| Not Named | 1949 | Oct | 3 |
| Debra | 1959 | Jul | 1 |
| Carla | 1961 | Sep | 3 |
| Celia | 1970 | Aug | 3 |
| Edith | 1971 | Sep | 1 |
| Fern | 1971 | Sep | 1 |
| Alicia | 1983 | Aug | 3 |
| Jerry | 1989 | Oct | 1 |

The paths of these storms are shown in Figure 2. Most of the paths, if slightly modified, had the potential to critically impact the site. If we include the past year 1990, there were 24 storms in 105 years which could potentially have affected Sargent Beach. Thus, on the average, there is the chance of 24/105 or 0.23 storms per year or approximately 1 storm every 4 years. These include all categories and all paths. Of course, storms do not occur with such regularity. The distribution of these storms in time is shown in Figure 3 for the period 1886 to 1990. From Figure 3, it is evident that there were periods of about 10 years without hurricanes and 2 years (1934 & 1971) when there were 2 in one year.

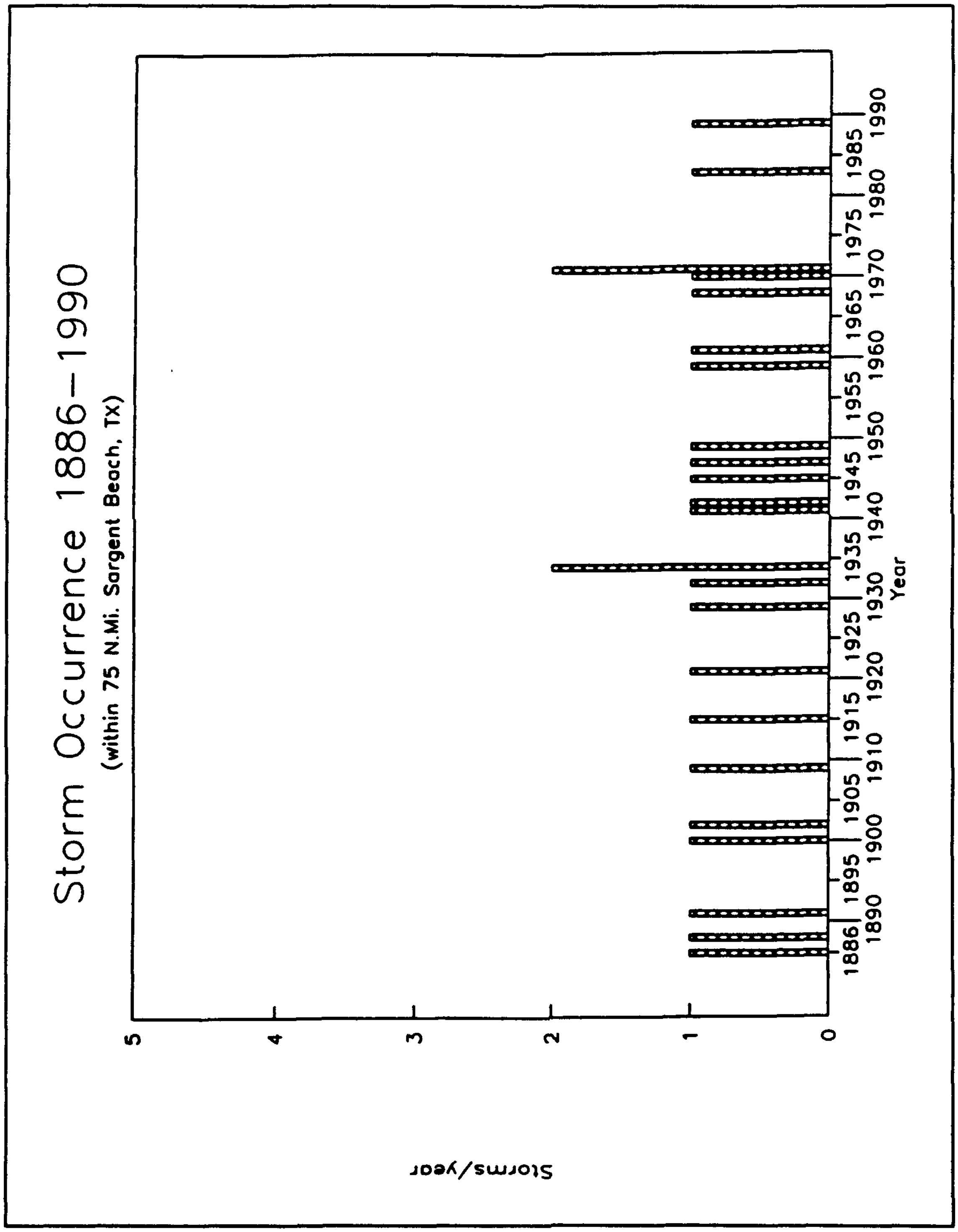



Figure 3. Occurrence of hurricanes by year

The distribution of these storms in time by category is shown in Figure 4. All categories, with the exception of 5 (the most severe), have occurred near the site. Most of the storms (17) are category 1, 1 of category 2, 5 of category 3, and 1 of category 4. There were 2 storms in the 1970's and 2 in the 1980's. If we project through the 1990's, we might expect 2-4 storms which could potentially affect the site. If so, this would average out to about 7 in 30 years as indicated by the historical data.

The National Hurricane Center has used all available historical data to estimate return periods for hurricanes of different category passing near this site. These estimates are shown in Figure 5. The three curves in this figure relate return period to maximum sustained wind speed near the storm center, which is related to storm category by Table 1. The curve labeled "75" gives return period for storms passing within 75 n.m. of Sargent Beach. The curve labeled "50" is for storms passing within 50 n.m. and the dashed curve is for storms passing over the site. The mean return periods for different storm categories shown in the box on the figure are estimated using the lower limit of wind speed for each category in Table 1 and the 75 n.m. curve. The return period intervals of 7, 14, 24, and 53 years for category 1-4 storms, respectively, were determined by the HURISK program. For consistency, these intervals were also used for water levels and wave heights.

## Water Levels

Water level at the coast normally varies due to the tide cycle during non-storm conditions. At Sargent Beach, this range from low to high tide is approximately 1.8 ft. When a hurricane approaches the coast, onshore winds blow the water up against the coast resulting in a storm surge. Low atmospheric pressures in the storm center and higher pressures surrounding the storm also cause an increase in water levels near the storm center. The combined effects of winds and pressures cause the storm surge which is superimposed on the tidal level to produce a total water level. Thus, the potential for damage (or erosion in this case) can either be increased or decreased depending on the stage of the tide. Other variables have a significant effect on the surge experienced at a particular location, even for the same size and category storm. These include: the extent and slope of the offshore bathymetry, with wider, shallower shelves producing higher surge; the angle of approach of the storm to the shoreline; the forward velocity of the storm, and in particular, the relative phase between the approaching storm surge and the tidal phase.

The large hurricane generated waves which break near the coast can also influence water levels. Water levels in the surf zone can be increased by waves setting up the water level when water is transported against the coast due to breaking. In addition, the effects of waves can bias, on the high side, the evidence of water levels. For example, debris lines may be higher on the beach due to wave runup than actual "still water" flood levels, or water marks on a structure may be higher due to splashing from waves than would occur in

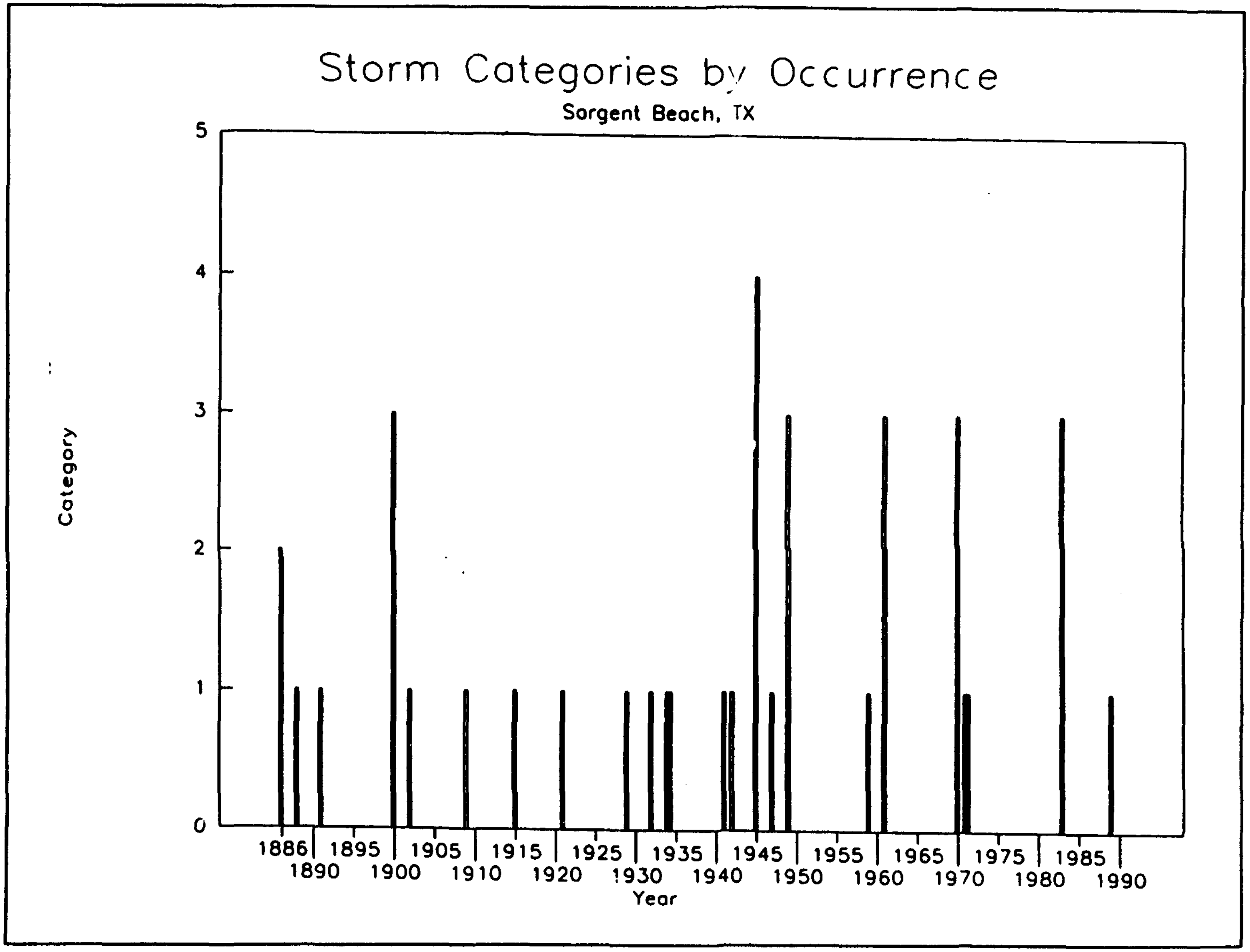



Figure 4. Categories of hurricanes by year

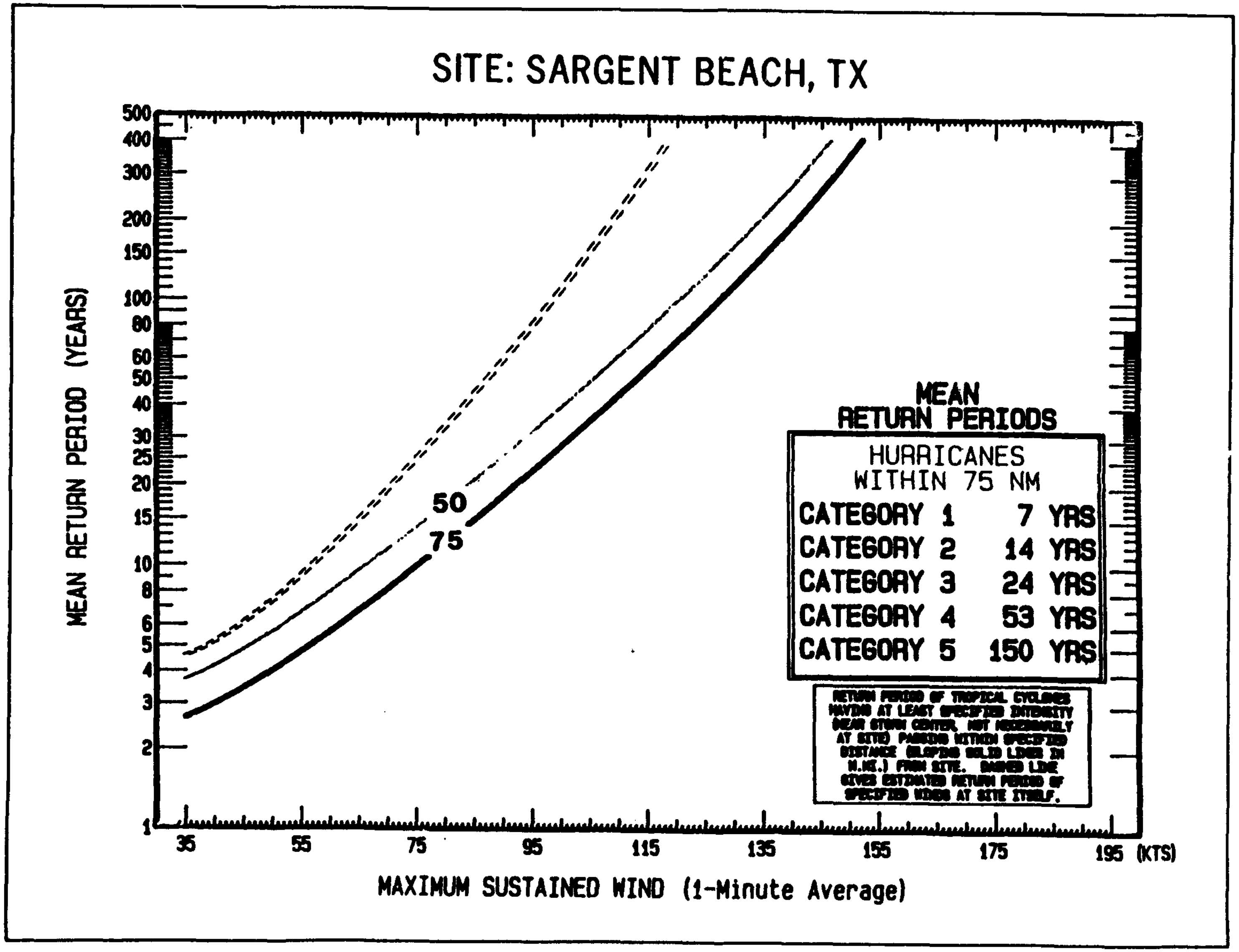



Figure 5. Mean return period versus maximum sustained wind speed

an area sheltered from wave activity. The best estimates of total still water level are obtained from tide gages.

The water levels estimated from numerical simulations of past or possible future storms are generally surge levels only. That is, they do not include the astronomic tide or possible effects due to waves. Observed water levels, however, do include the tide and wave effects. Thus, estimates of water levels in studies such as this must be interpreted in terms of their origin and care taken when comparing model and observed results. Unfortunately, no model studies have been done to estimate hurricane surge for this site, so we have to rely solely on observations.

Gage-recorded water levels from 5 storms near Sargent Beach are shown in Figure 6. The storms depicted in Figure 6 are October 1949 (Harris 1963), Carla (USAED, Galveston 1962), Celia (USAED, Galveston 1971), Fern (Simpson and Hope 1972), and Alicia (National Research Council 1983). These 5 storms offered the most reliable and complete water level records for the storms passing within the 75-n.m. radius of Sargent Beach. The October 1949 storm and Fern in 1971 had paths which put Sargent Beach in the right front quadrant. The other storms passed close to the site, but not on critical paths for the site. For each storm, we have chosen the higher water levels in the right front quadrant as representative of the maximum water levels for these category storms along this reach of coastline. These values are plotted in Figure 7 versus storm category. Water levels in bay areas can differ significantly from those along the open coast due to local bathymetry, sheltering, etc. These values were not included since they did not affect the project site.

For Figure 7 to apply to Sargent Beach, it is assumed that all of the storms had paths which put Sargent Beach in the region of highest water levels. For large storms such as Carla, high water levels extended for miles along the coast away from the landfall point. This is illustrated in Figure 8 which shows the results of a numerical simulation of surge levels to the right of landfall for Carla. Thus, return periods associated with storms hitting within 75 n.m. would be appropriate. These estimates of water levels were obtained from the National Oceanic and Atmospheric Administration (NOAA) storm surge numerical model SLOSH. For smaller storms, the higher water levels are confined to a shorter reach of coastline and a more direct hit and possibly longer return period would be appropriate.

If we assume the return periods associated with storms approaching within 75-n.m. are appropriate, then at Sargent Beach, one could expect total water levels of 4-6 ft above mean sea level to have a return period of about 7 years, 6-8 ft 14 years, 8-12 ft 24 years, and if we extrapolate 14-16 ft 53 years. This estimated water-level envelope and associated return periods are shown in Figure 9.

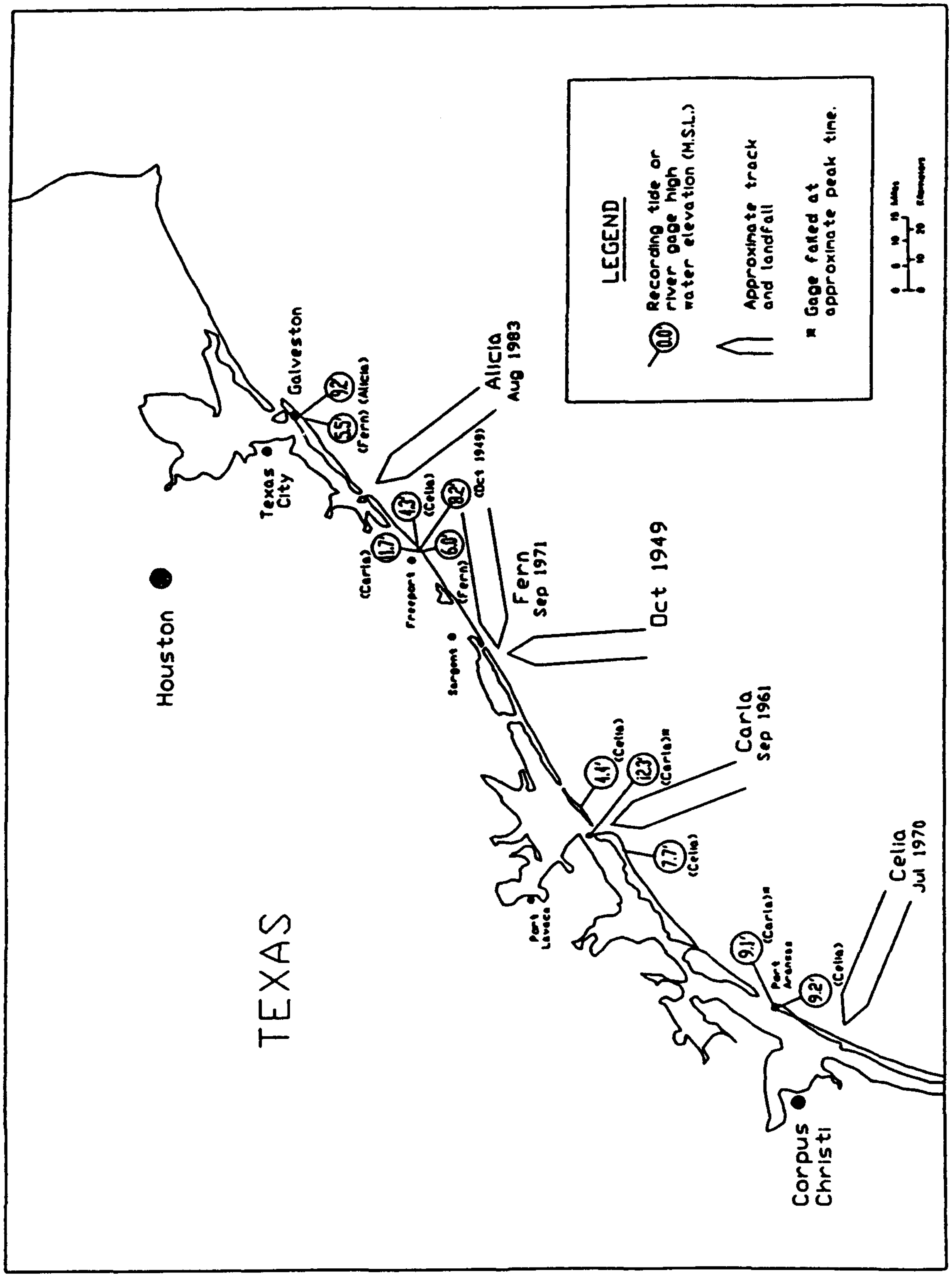



Figure 6. Measured water levels for hurricanes making landfall near Sargent Beach, TX

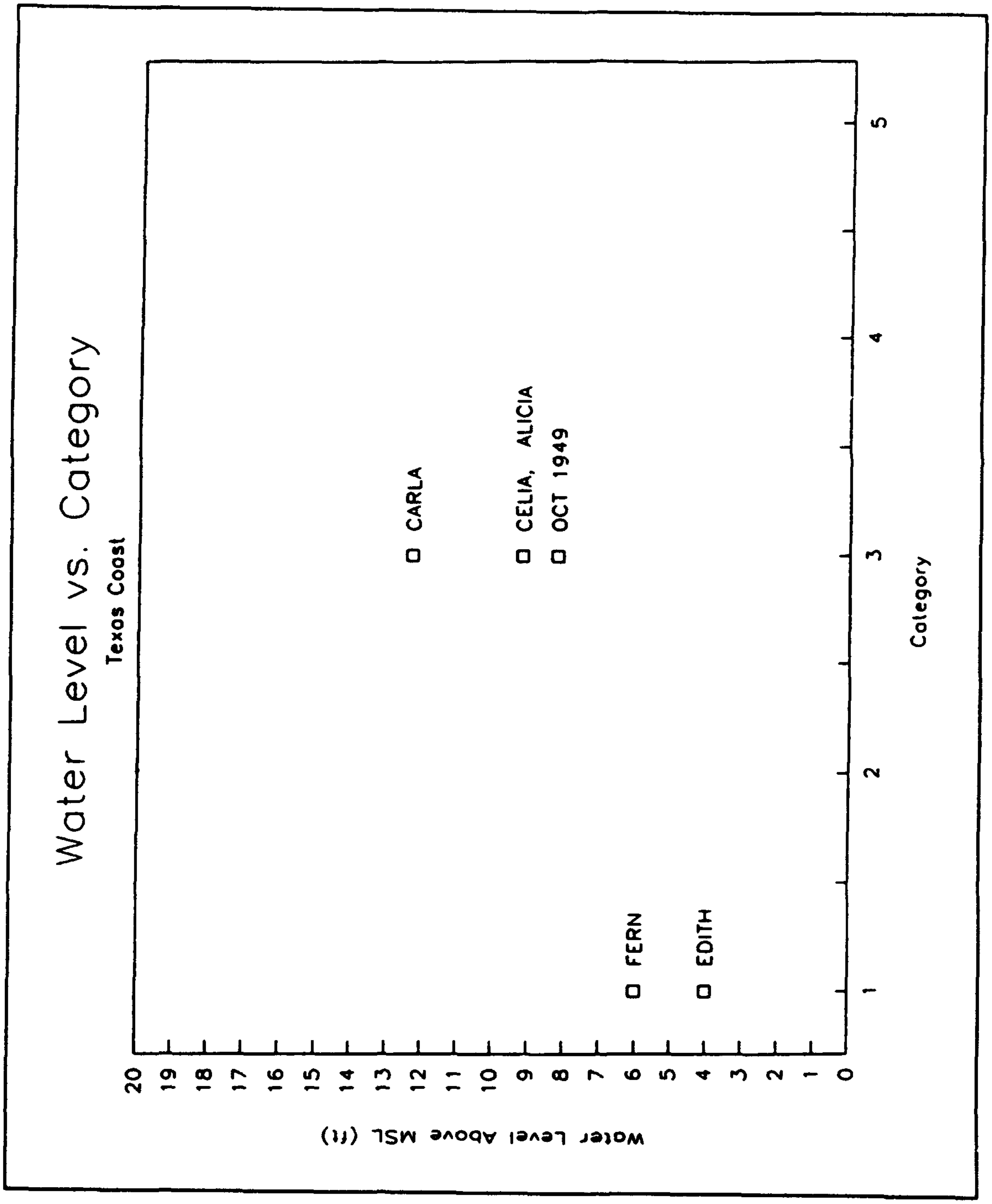



Figure 7. Water level versus storm category for hurricanes near Sargent Beach, TX

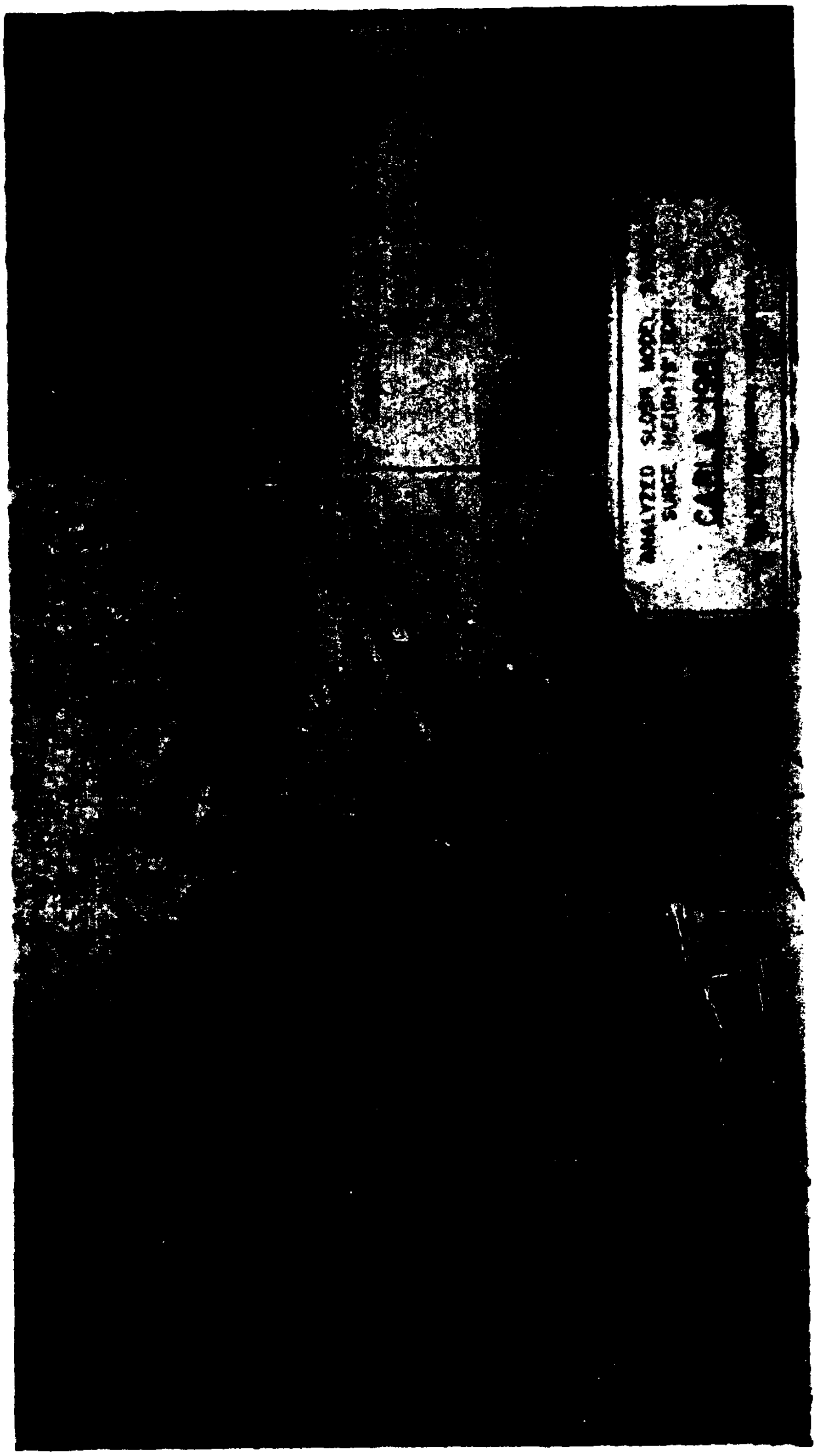



Figure 8. Numerical model results of surge levels for Hurricane Carla

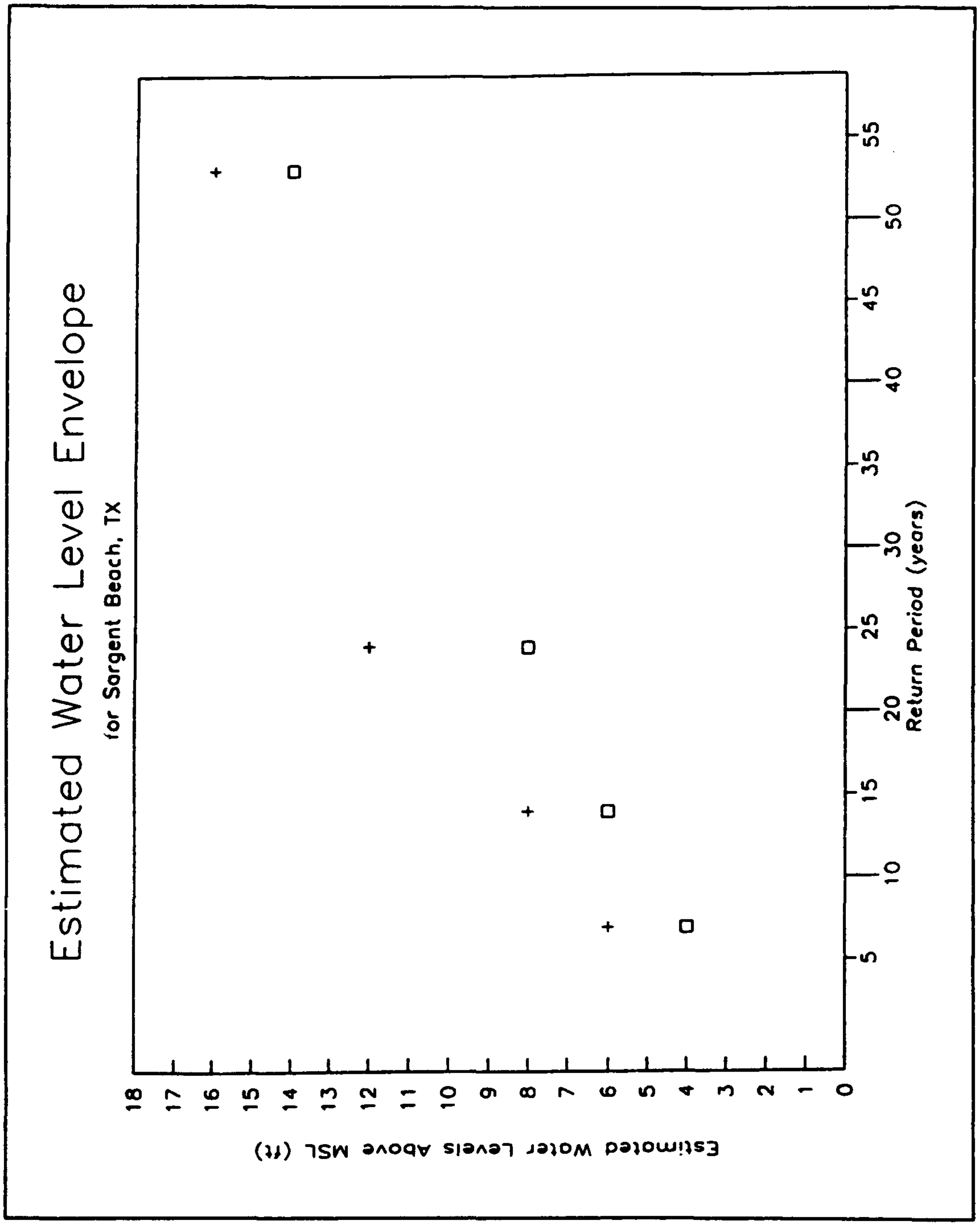



Figure 9. Estimated water-level envelope versus return periods for Sargent Beach, TX

## Wave Information

Measured or observed wave conditions during hurricanes are more scarce than water level information. The best source of wave information near the site during hurricanes is contained in WIS Report 19 (Abel et. al. 1989) and the database on which the report is based. The revised values in the addendum to the report were used. Twenty-five hurricanes were simulated during the hindcast time period (1956-1975) all of which, except one, caused high wave energy at the hindcast station closest to the project site. This is station 9 located at 28.5 deg N, 95.5 deg W. This location is approximately 15 n.m. offshore in a depth of about 85 ft. These results were used to estimate return period wave heights and associated peak periods at this station. Estimates of the lower limit of the peak period for each wave height were obtained using Equation 15 from WIS Report 15 (Corson and Tracy 1985). These results are summarized in Figure 10.

These conditions, of course, only apply at this location. As one moves toward shore, and the depths decrease, the wave energy will be limited by some percentage of the water depth. Generally, this percentage ranges from 60 to 80%. None of the wave heights at station 9 in Figure 10 are depth limited, that is, they do not exceed 0.6 to 0.8 of the depth of 85 ft or 51 to 68 ft, respectively.

An assumption for this study is that mean wave heights at the project site (or zero mean sea level) will be depth limited by the total water level, that is surge plus tide. Assuming a tide at mean sea level and a percentage of 0.8 for a depth limited mean wave height, we could expect wave heights at the shoreline to be 3-5 ft for a return period of 7 years, 5-6.5 ft for 14 years, 6.5-9.5 ft for 24 years, and 11-13 ft for 53 years.

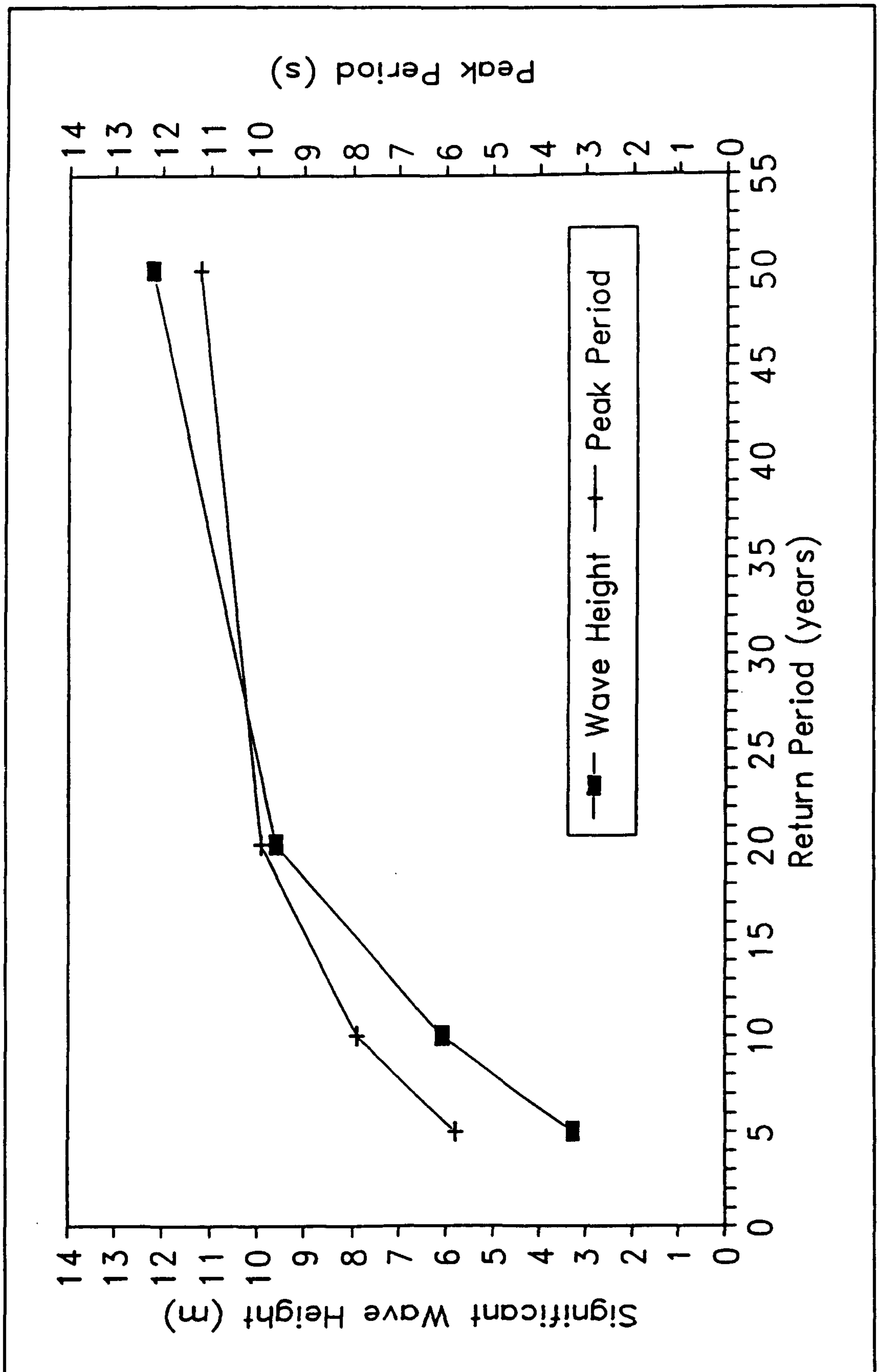



Figure 10. Wave heights and periods versus return periods for WIS Gulf station 9

# 3 Shoreline Change Analysis and Sediment Distribution

## Introduction

One of the highest areas of coastal erosion along the Texas coast is located in the deltaic headland coastal segment of the Brazos River in the vicinity of Sargent Beach (Figure 11). Because of this erosion, a section of the Gulf Intracoastal Waterway (GIWW) from Cedar Lakes to East Matagorda Bay is in danger of intrusion from breaching of the narrow (less than 1,000 ft wide) shorefront. Numerous beach profile studies have been carried out over the years, resulting in several sets of survey markers in place along the study area. Figure 12 shows the details of the study area and profile locations, with the various numbering schemes. Owing to its deltaic origin, the beach is composed of cohesive fine grained clayey-silt material, overlain by a thin layer of coastal peat and topped by a thin veneer of fine grained quartz beach sand with a high percentage of shell fragments. The original dredging of the GIWW produced a "barrier island" with a low elevation, moderately vegetated interior. Dredge material was placed on the beach side of the GIWW, which results in mounds that have the highest elevations on the barrier island and are located adjacent to the GIWW.

The central part of the island has numerous overwash terraces. Low incipient dunes are found near the mean high water line and berm crest. The foreshore beach from berm crest to NGVD ranges from 150 to 200 ft wide. Along portions of the beach around survey markers S-30 to S-18, the thin sand veneer extends into the water. Along the portions of the beach in the vicinity of S-18 to S-12, exposed surf zone marsh mud forms a low wave cut terrace with a highly irregular vertical face. The wave cut scarp meanders alongshore irregularly with indentations or mini-pocket beaches of sand. There is some rhythmic pattern to these pocket beaches, that all trend on a 45 deg angle toward the northeast from the shoreline.

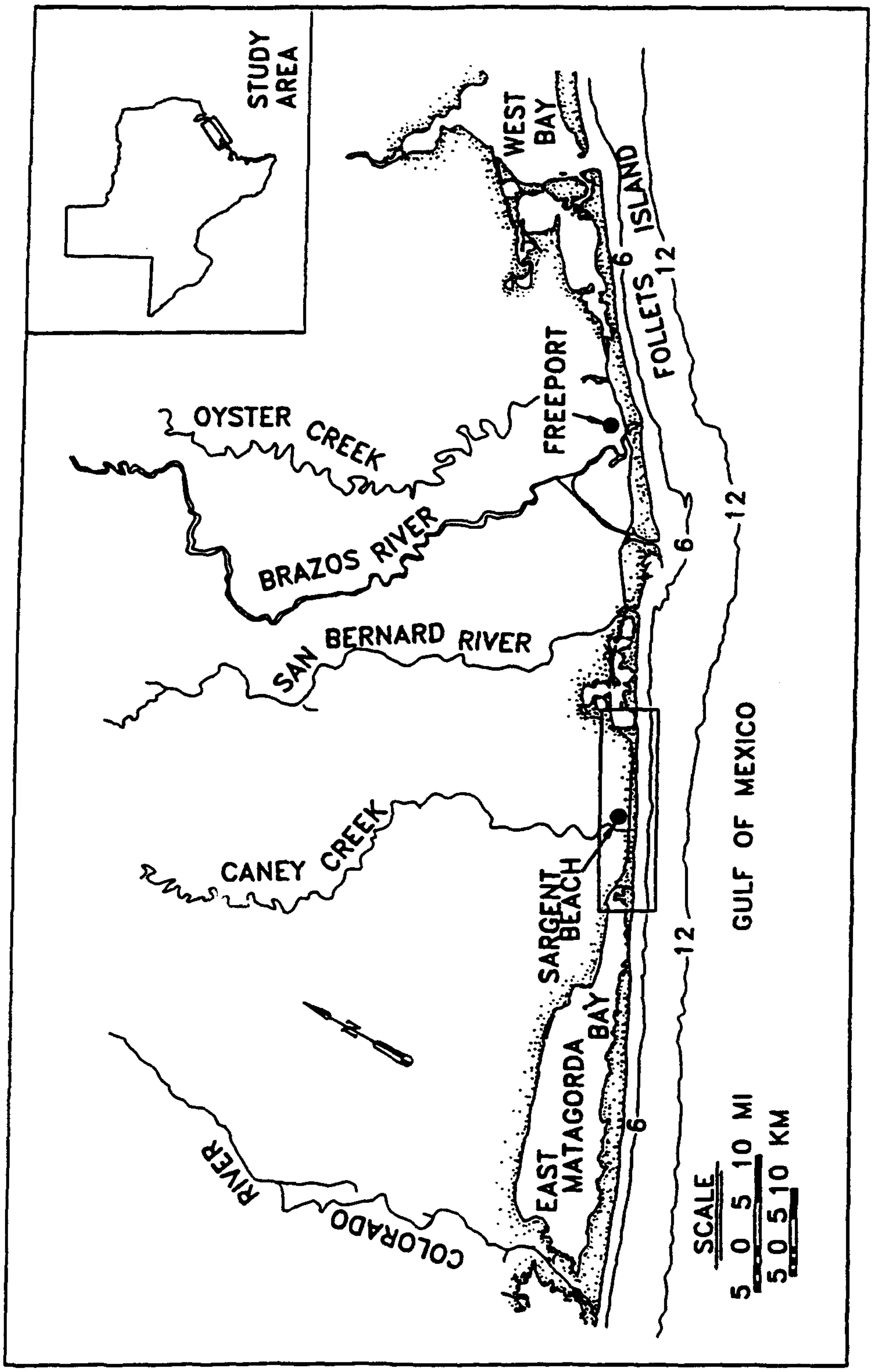



Figure 11. Location of study area on the deltaic headland between the Brazos and Colorado Rivers

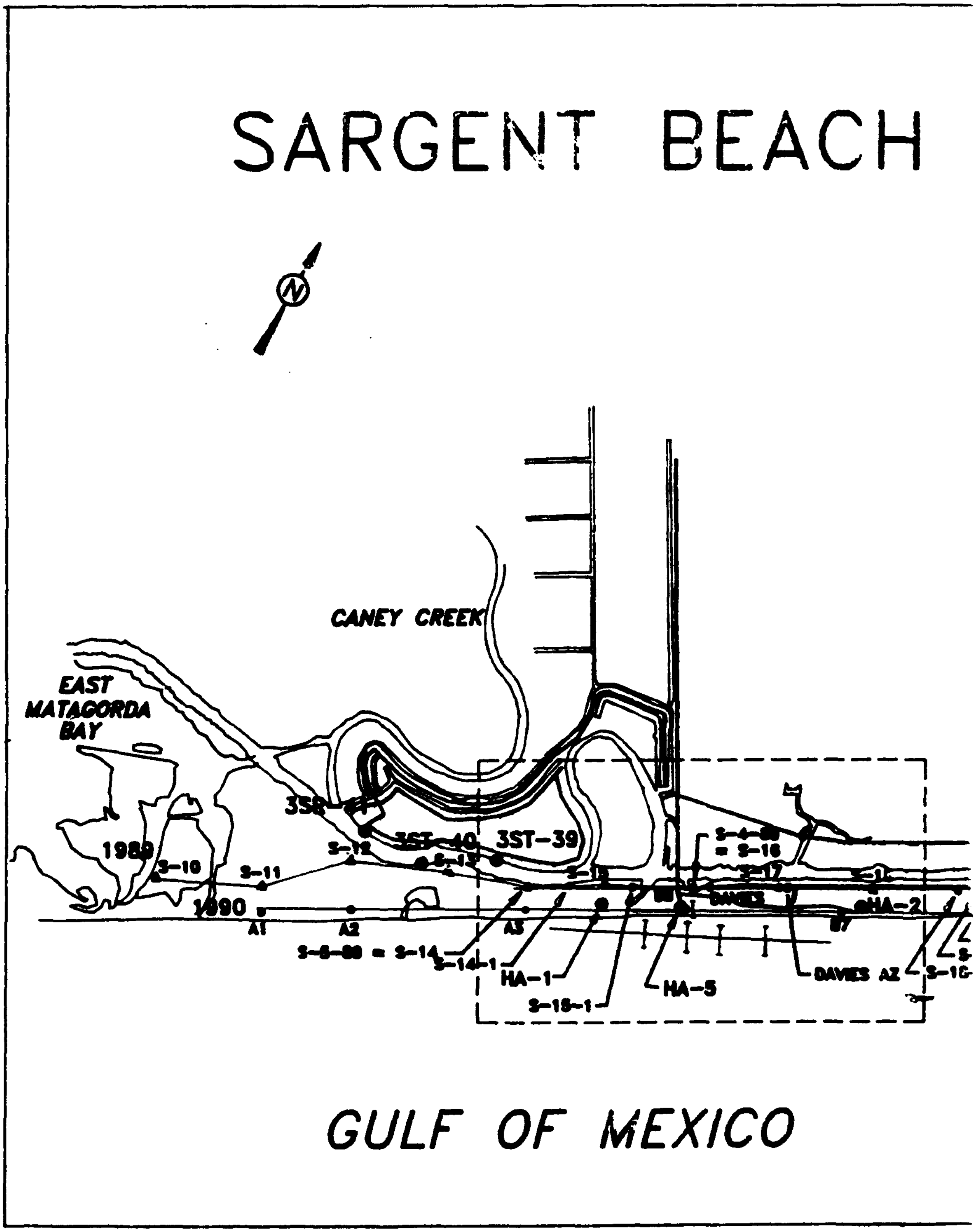
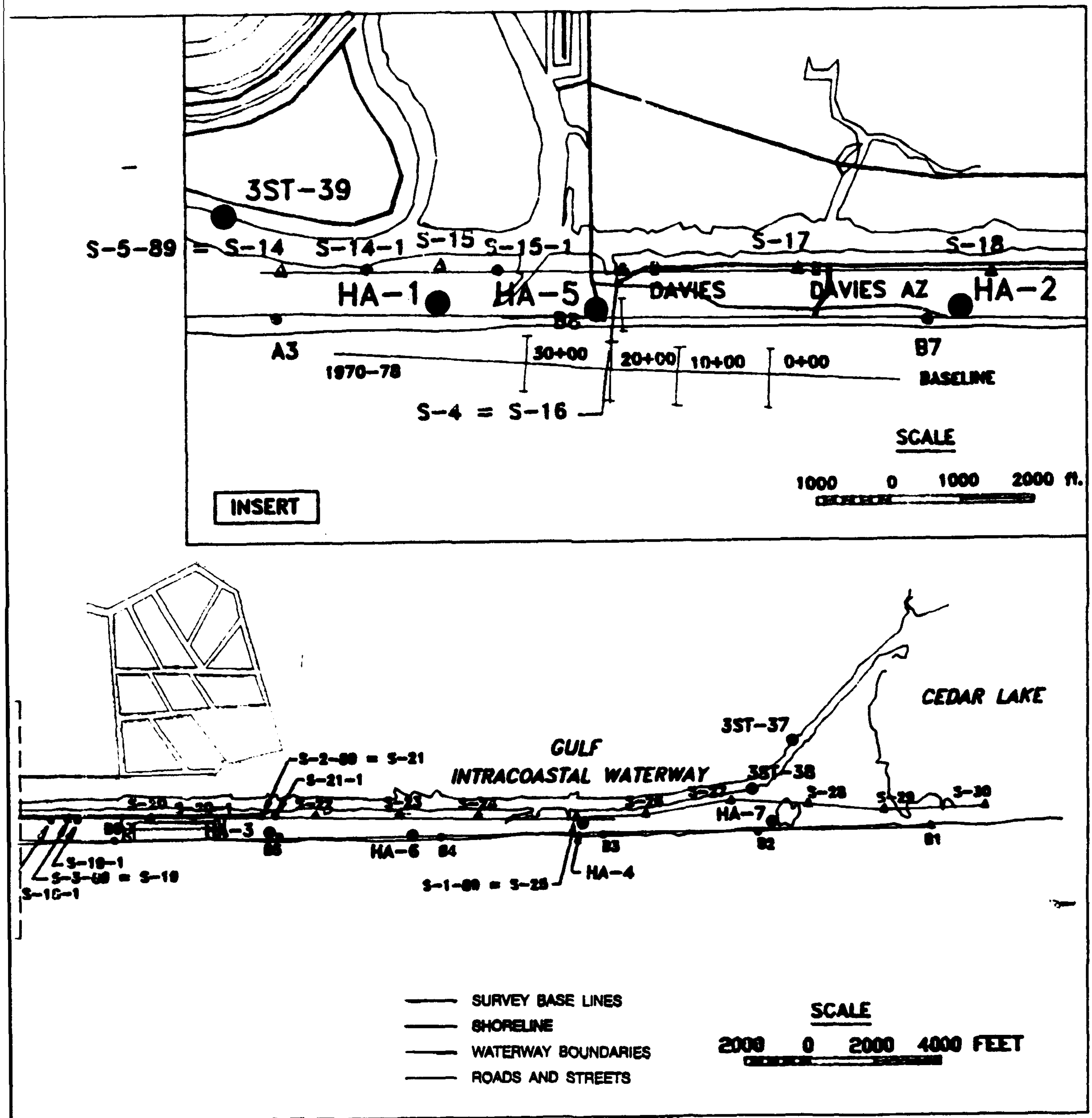



Figure 12. Detailed map of study area with past survey benchmark locations. Insert expands the built up a




it up area of Sargent Beach

## Shoreline Analysis

In order to assess the change in shoreline over time, aerial photographs have been studied, ranging from 1943 to 1989 (Table 3). The high water line was used as it is the easiest to distinguish on the aerial photographs. The dune or vegetation line was also mapped, as the study by Fields et al. (1990) found that the vegetation line retreated significant distances landward. The latest available photography was the 1989 color IR set.

**Table 3**
**Aerial Photography**

| Date | Scale | Type |
|---|---|---|
| 10/16 - 17/43 | 1:18000 | Black and White |
| 3/20/58 | 1:21000 | Black and White |
| 10/30/65 | 1:21000 | Black and White |
| 11/29/71,<br>11/14/75 | 1:41520 | Black and White |
| 10/31/85 or | 1:26200 | Color |
| 1/13/86 | 1:12000 | Color |
| 12/ /89 | 1:24000 | Color IR |

### Shoreline position mapping

The positions of the high water line and duneline for the northeast half of the study area from Cedar Lake to Charpiot's Cut is shown in Figure 13. The trend is erosional along this entire length as both the high water line and duneline retreat landward through time. Charpiot's Cut developed after the 1971 aerial photographs were taken as the shoreline retreated into a man-made marina area dredged in to the barrier. The shoreline became even with the beachside channel and eroded further landward, creating an inlet where the shore normal connecting channel for the marina intersected the retreating shoreline. This Cut remained open on the 1985/86 photography but closed by natural sedimentation processes in 1989. The duneline retreat exhibits a more irregular pattern as storm waves impacted the vegetation line and created overwash channels. As the shoreline and duneline have retreated, the island has narrowed and small lakes or ponds on the back shore area are now exposed to the active beach processes. Since these are low areas, the potential exists for possible island breaching and new inlet formation after an extreme event.

The shoreline positions of the southwest portion of the study area from Charpiot's Cut to the new inlet into East Matagorda Bay are shown in Figure 14. Again the shoreline and duneline retreat in a landward direction over the study period. This landward retreat has caused erosion of the end of

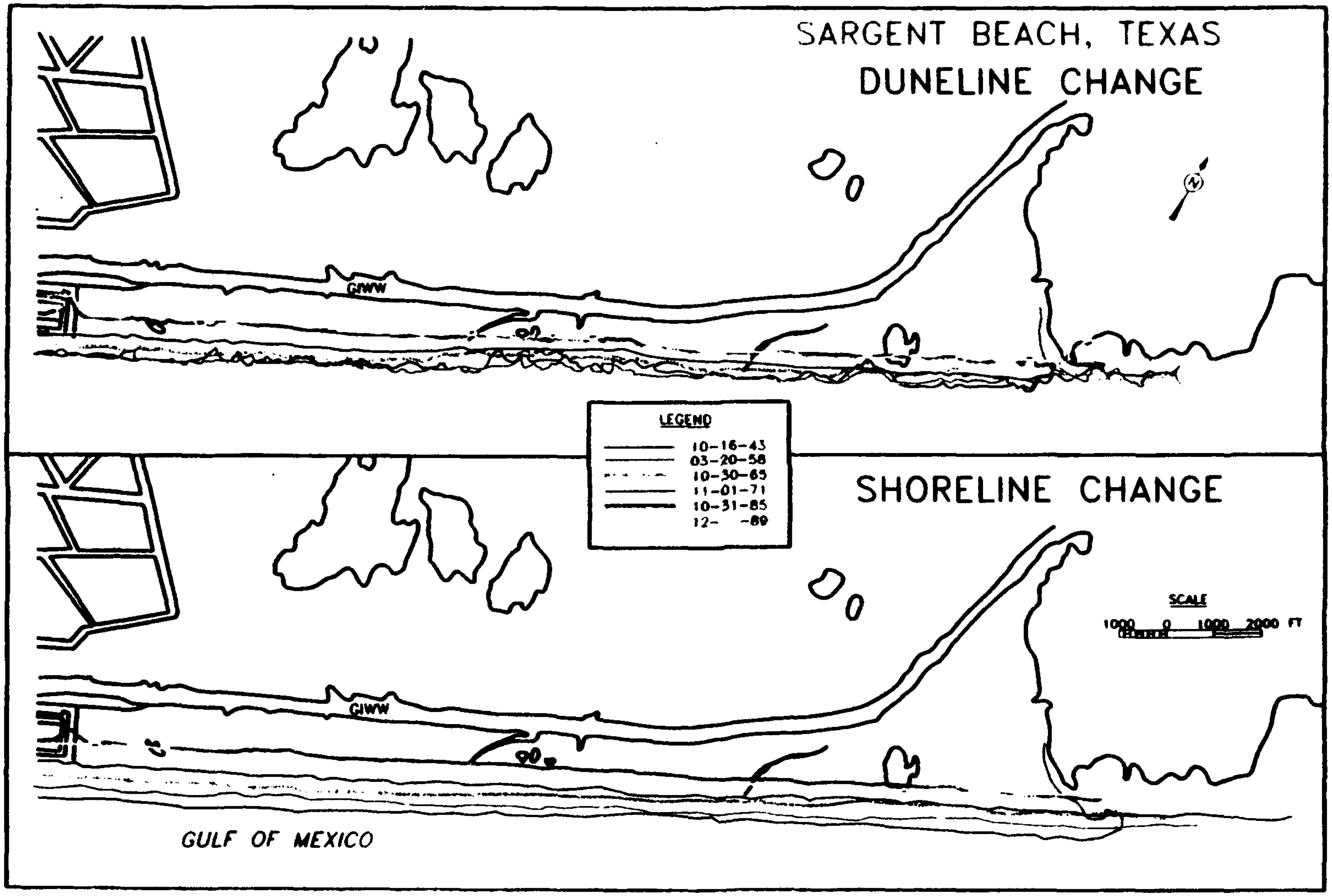



Figure 13. High-water line (shoreline) and duneline (vegetation) positions for the northwest portion of study area from Cedar Lake to Charpiot's Cut

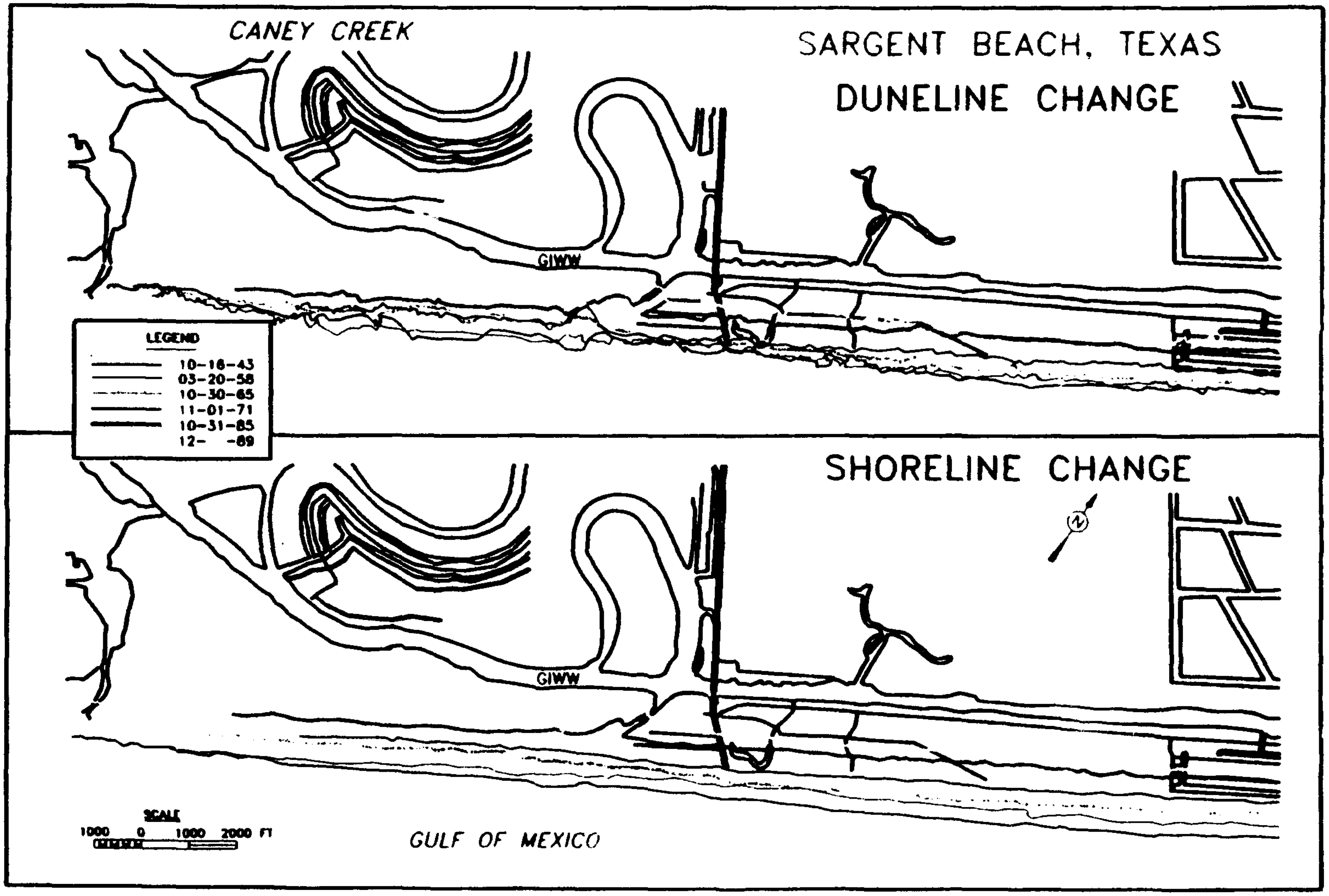



Figure 14. High-water line (shoreline) and duneline (vegetation) positions for the southeast portion of study area from Charpiot's Cut to East Matagorda Bay

highway FM 457 and the loss of a several houses and two streets in a small community developed on the barrier in the vicinity of the highway bridge. McCabe's Cut was dredged open in 1983 and mechanically closed in March 1989. The narrowest portion of the barrier island with the lowest elevation is in the vicinity of this cut.

The process of inlet formation and closure is common along this coast. An inlet into Cedar Lake existed on the 1943 photographs (red line on Figure 13) which was closed by the 1958 photography and has remained closed to present day. As is common in inlet closure, the tidal flow in and out of the inlet has less energy than the alongshore wave induced sediment transport and deposition across the opening occurs. This natural process of inlet closure has also taken place at Charpiot's Cut. McCabe's Cut, in close proximity to Caney Creek, had enough tidal flow to maintain the inlet and also interfered with navigation through the highway bridge and had to be closed in 1989 by mechanical means. Brown Cedar Cut located further to the southwest into East Matagorda Bay has alternately been open and is now closed and a new inlet at the extreme southwest edge of the study area has been opened to provide navigational access to the Gulf.

### Shoreline change analysis

The shoreline change analysis was done by digitizing each high water line drawn on base maps using a zoom transfer scope from the aerial photographs and using the COAST program to calculate areas and distances. To assess any spatial variability, the study area shoreline was divided into 2000 foot interval transects for measurement purposes (Figure 15). Transect 1 is located on the northeast end of the project at Cedar Lake. Charpiot's Cut is in the vicinity of Transect 11 and McCabe's Cut is near Transect 18. Transect 21 is located 6,000 ft southwest of the cut around survey marker S-12. The shoreline change analysis ended here, as this was the extent of coverage on some of the aerial photographs.

The maximum landward movement was found in the vicinity of McCabe's Cut, where the island is the narrowest. From 1943 to 1989 the high water line has moved landward 1,654 ft at Transect 18 (Figure 16 and Table 4). The next largest movement of the high water line was 1481 ft at Charpiot's Cut. The alongshore distribution shows that there is a greater landward movement between the two cuts, than to the shoreline at the northeast section and to some extent Transects 20 and 21 at the southwest end. The smallest landward excursion since 1943 of the high water line was at Transect 3 with a distance of 920 ft. The segment of shoreline with the greatest landward movement corresponds to the length of shoreline with the exposed low tide mud terrace, with its low vertical scarps. The shoreline to the northeast and southeast contain a thin sand veneer over the deltaic mud out into the surf zone, which presents a more typical smooth slope. An examination of the shoreline movement for the more recent 24 year period from 1965 to 1989 shows the same general higher erosion trend for the central portion of the study area

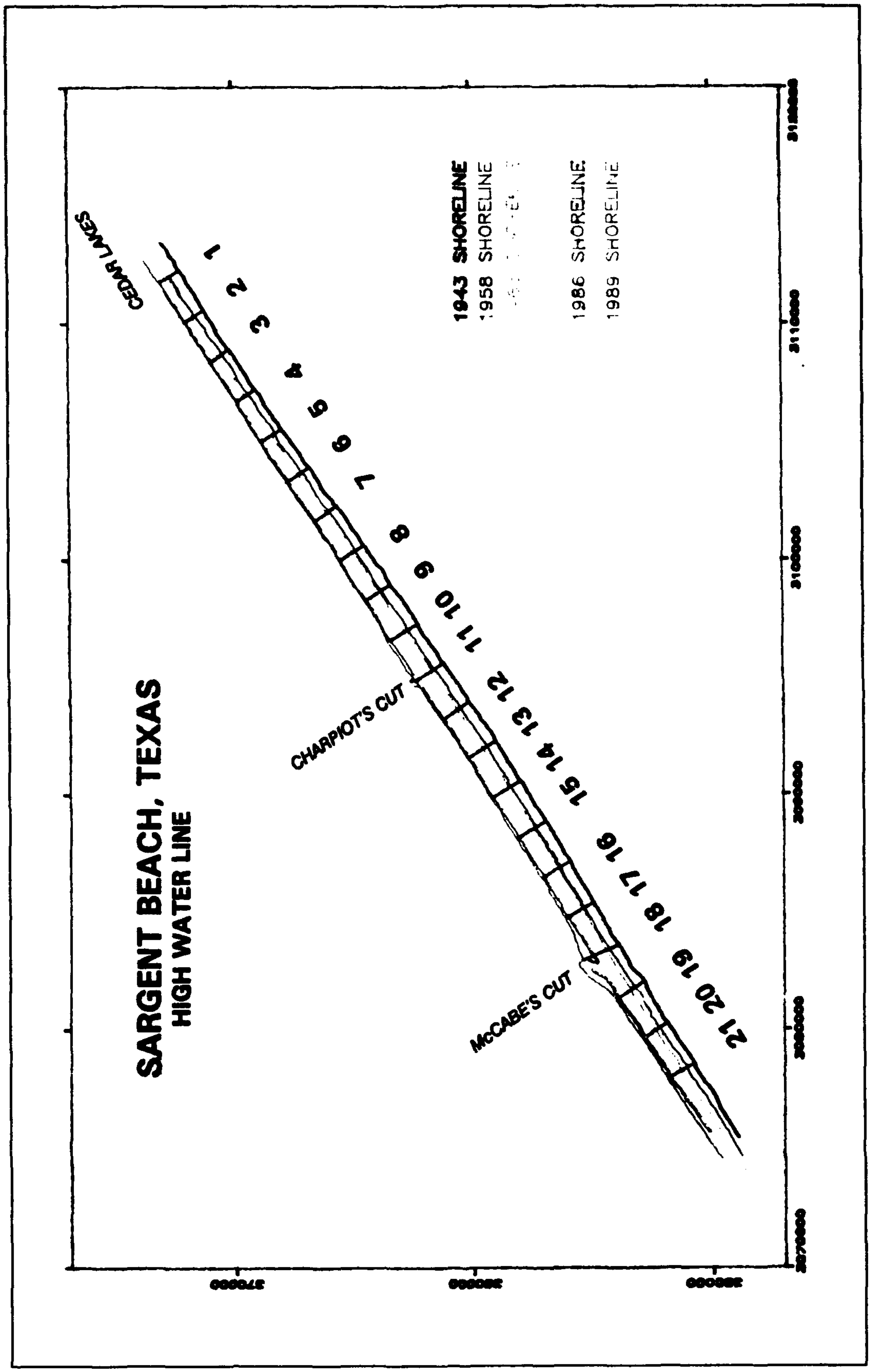



Figure 15. Transect locations for shoreline analysis

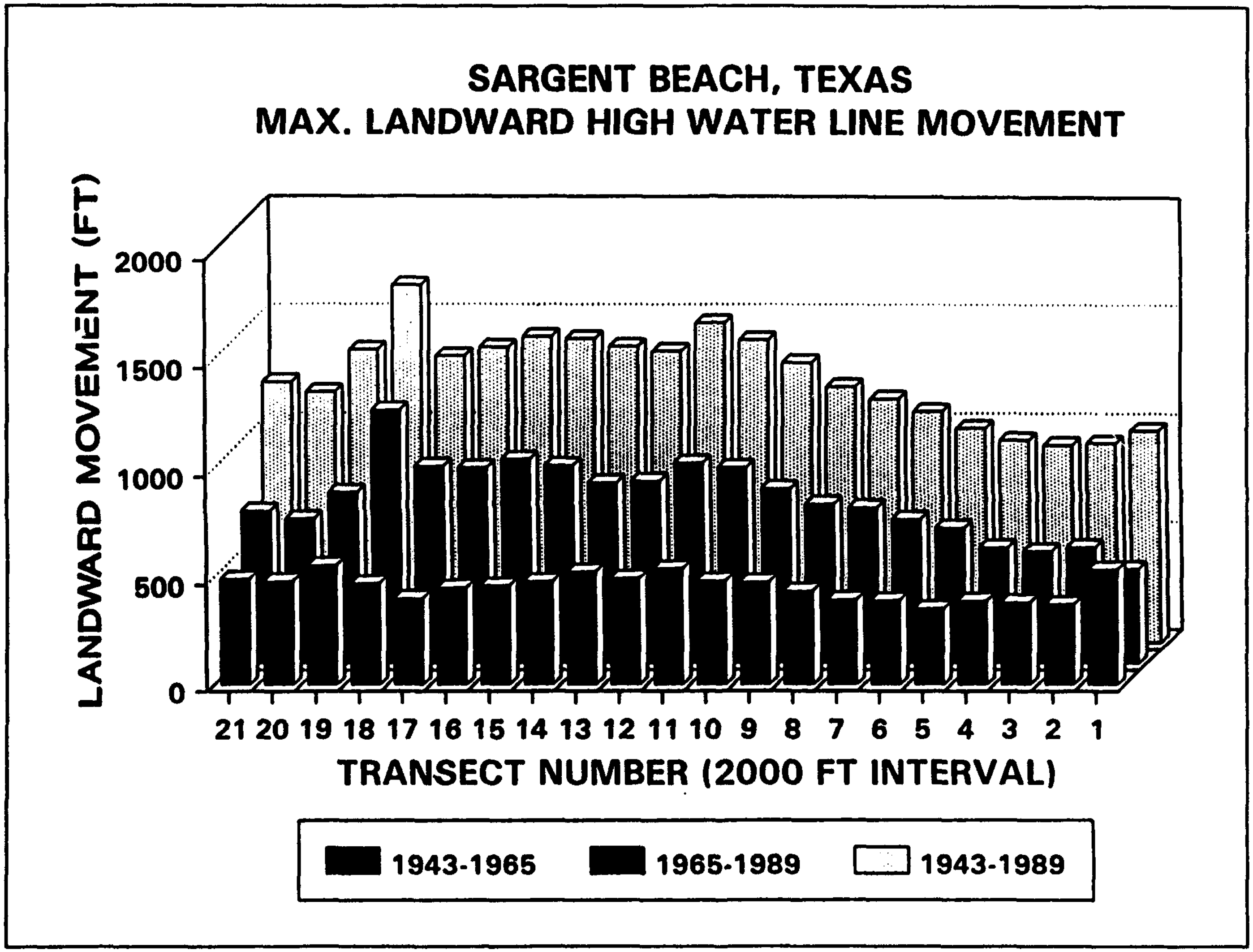



Figure 16. Maximum landward movement of the high-water line over the entire 46 year study period from 1943 to 1989, last 24 years from 1965 to 1989, and first 22 years from 1943 to 1965 for each transect

| Table 4<br>Shoreline Statistics | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | (units in ft/yr[2]) | | | | | |
| Transect Number | Maximum Movement[1] (ft) | 1943-1958 | 1958-1965 | 1965-1971 | 1971-1986 | 1986-1989 | Ave. Movement 1943-1989 |
| 1 | 988.0 | -28.4 | -16.7 | -18.5 | ---- | ---- | -21.5 |
| 2 | 929.6 | -26.1 | -19.8 | -19.8 | -18.7 | 10.2 | -19.6 |
| 3 | 920.1 | -18.3 | -23.5 | -38.2 | -16.7 | -0.8 | -20.0 |
| 4 | 942.9 | -20.3 | -16.0 | -25.9 | -24.0 | -3.8 | -20.5 |
| 5 | 998.1 | -16.7 | -16.0 | -27.1 | -29.9 | -7.8 | -21.7 |
| 6 | 1,073.4 | -20.4 | -20.6 | -32.3 | -28.0 | -2.9 | -23.3 |
| 7 | 1,130.0 | -21.5 | -13.3 | -57.1 | -28.3 | -2.9 | -24.6 |
| 8 | 1,185.8 | -23.2 | -13.4 | -43.5 | -29.3 | -14.6 | -25.8 |
| 9 | 1,296.8 | -29.2 | -6.3 | -45.3 | -35.1 | -5.4 | -28.2 |
| 10 | 1,402.3 | -25.7 | -14.6 | -49.5 | -34.5 | -33.6 | -30.5 |
| 11 | 1,480.9 | -27.0 | -12.8 | -53.7 | -44.2 | 46.0 | -29.2 |
| 12 | 1,351.0 | -25.4 | -16.9 | -56.9 | -33.2 | -4.1 | -29.4 |
| 13 | 1,372.9 | -25.5 | -21.2 | -52.7 | -32.4 | -13.5 | -29.9 |
| 14 | 1,408.6 | -29.5 | -6.1 | -53.1 | -35.0 | -26.6 | -30.6 |
| 15 | 1,417.5 | -29.9 | -2.3 | -61.9 | -32.8 | -29.7 | -30.8 |
| 16 | 1,368.0 | -32.2 | 3.8 | -44.5 | -35.8 | -36.4 | -29.7 |
| 17 | 1,327.4 | -26.1 | -2.3 | -40.3 | -38.0 | -36.1 | -28.9 |
| 18 | 1,654.0 | -23.4 | -17.9 | -27.2 | -34.3 | -166.8 | -36.0 |
| 19 | 1,357.9 | -25.3 | -25.7 | -41.1 | -29.7 | -p35.9 | -29.5 |
| 20 | 1,161.0 | -19.7 | -27.1 | -32.6 | -27.4 | -22.8 | -25.2 |
| 21 | 1,206.6 | -17.0 | -34.4 | -35.5 | -26.6 | -33.0 | -26.2 |
| Ave Value | 1,236.7 | -24.2 | -25.3 | -40.3 | -30.7 | -21.0 | -25.5 |

[1] Maximum movement is distance between most gulfward and landward shoreline position over study period.
[2] Negative numbers indicate landward movement, positive numbers indicate gulfward movement.

(Figure 16). The highest rate was again at McCabe's Cut. Except for the ends of the study area, more than half of the landward retreat distance has occurred since 1965.

## Shoreline change rates

The average rate of shoreline movement has been variable in the alongshore direction over the 46 year study period. The largest average rate of erosion was measured as 37.0 ft/yr again at Transect 18 (Figure 17a and Table 4). The greatest variability was also measured here resulting from the

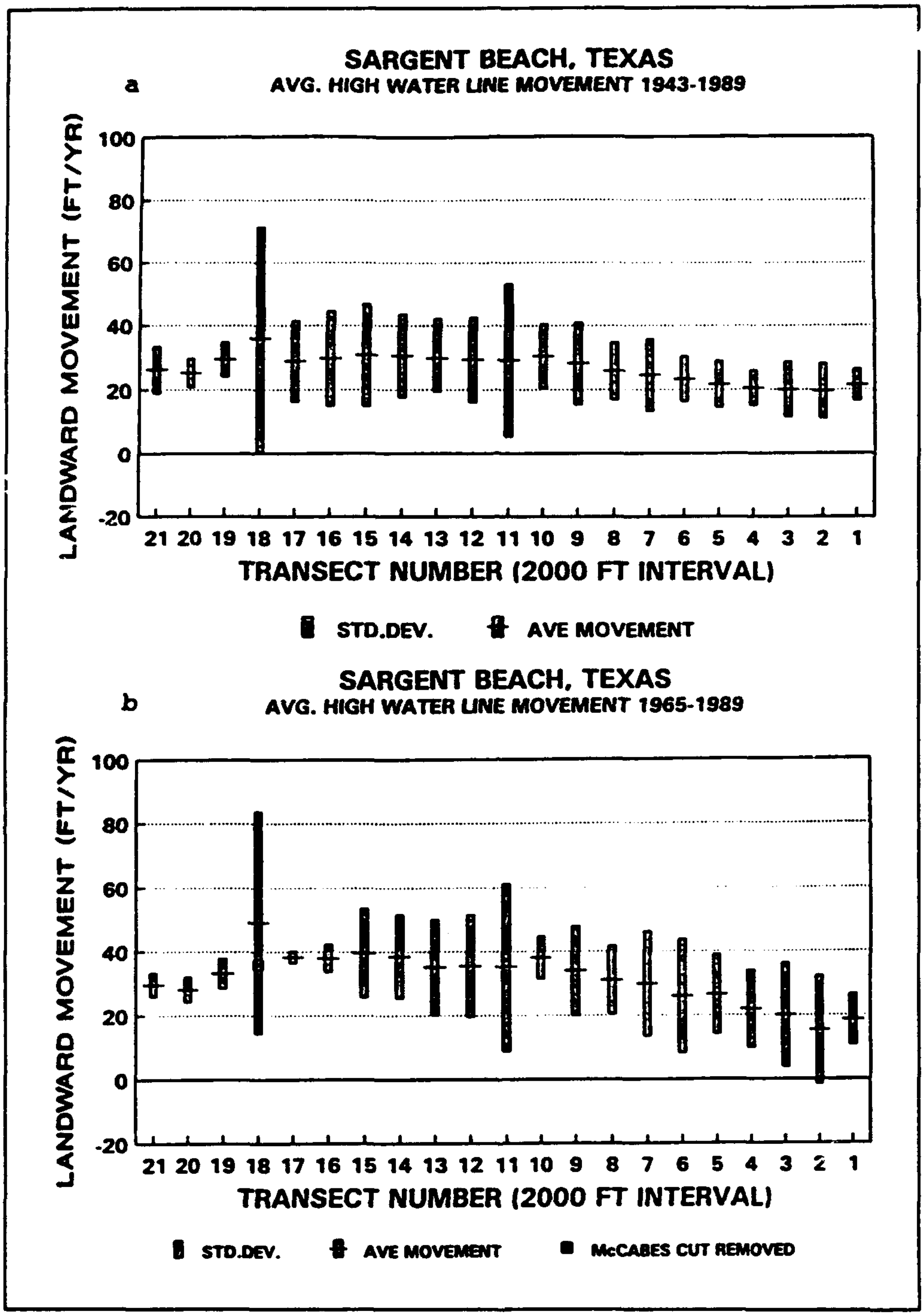



Figure 17. Average rate of high-water line movement over the (a) entire 46 year study, and (b) most recent 24 years for each of the transects. Averaging out the high variability of McCabe's Cut reduces the rate at station 18. Length of bars indicate standard deviation about mean for each transect

influence of the opening and closing of McCabe's Cut. The second largest erosion rate of 30.5 ft/yr was measured at Transect 10 located 2000 ft northeast of Charpiot's Cut. The second greatest variability was measured at the Cut (Transect 11) again owing to the erosion of the beach into the marina channel and its subsequent closure. The smallest erosion rate was measured at Transect 2 with 19.6 ft/yr. Transects 1 and 20 had the least amount of variability in shoreline erosion. The rates of erosion over the 46 year study average 22.8 ft/yr for Transects 1 to 8 in the northeast and Transects 20 and 21 in the southeast. The area between the Cuts (Transects 9 to 19) average a higher 30.2 ft/yr. The overall average shoreline erosion for the entire study area (Transects 1-21) over the 46 year period is 25.5 ft/yr. The higher rate of erosion between the Cuts corresponds to the type of shoreline composition. The "terraced" mud deposits break off and cut back at a higher rate than the sand beach material.

The erosion rate for the most recent 24 year period follows a similar pattern to the long term study, but all of the transects exhibited higher rates except for Transects 1-3 at the northeast end of the study (Figure 17b). The highest rate was again at McCabe's Cut (Transect 18) at 49.1 ft/yr, with the greatest variability. The variability was reduced by averaging the rate at Transect 17 with Transect 19 to give a rate of 36.0 ft/yr as a way of filtering out the influence of the opening and closing of the cut. Charpiot's Cut (Transect 11) again had the second highest rate at 39.3 ft/yr. The transects located between the cuts had higher rates than the ends of the study area, with the lowest erosion rates at the northeastern end (Transects 1-6). Lower variability was measured at the southwestern end at Transects 16 through 21 (excluding McCabe's Cut-Transect 18). The 24 year average erosion rates were slightly higher for Transects 1 to 8 at 25.0 ft/yr and the area between the Cuts (Transect 9 to 19) at 36.0 ft/yr. The overall average shoreline erosion for the entire study area (Transects 1-21) over the 24 year period is 30.0 ft/yr.

To better understand both the temporal and spatial variability in the erosion rate at Sargent Beach, calculations for each transect were done between each set of aerial photographs. Figure 18a contains the average high water line movement for each transect from the period 1943-1958 and from 1958-1965. The erosion during the first 15 year period showed that the beach moved landward at a fairly constant rate along the entire study section. The second time period of 7 years showed that the rate of erosion had slowed with the area between Transects 14 and 17 exhibiting almost no change. Transect 16 showed a slight accretional rate. This time period had the smallest erosion rates during the study. During the six year period 1965-1971 (Figure 18b) the Sargent beach area experienced its largest increase in erosion rate. Almost all of the transects show a gain in the rate of landward movement, with the greatest rates between Transects 7 and 18. A Category 3 hurricane, Celia made land fall in Corpus Christi Bay (150 miles to the southwest) on 3 August 1970 and a Category 1 hurricane, Fern made land fall 50 miles to the southwest near Port O'Connor in Matagorda Bay and traveled along the shoreline to the southwest on 10 September 1971 (Neumann et al. 1978).

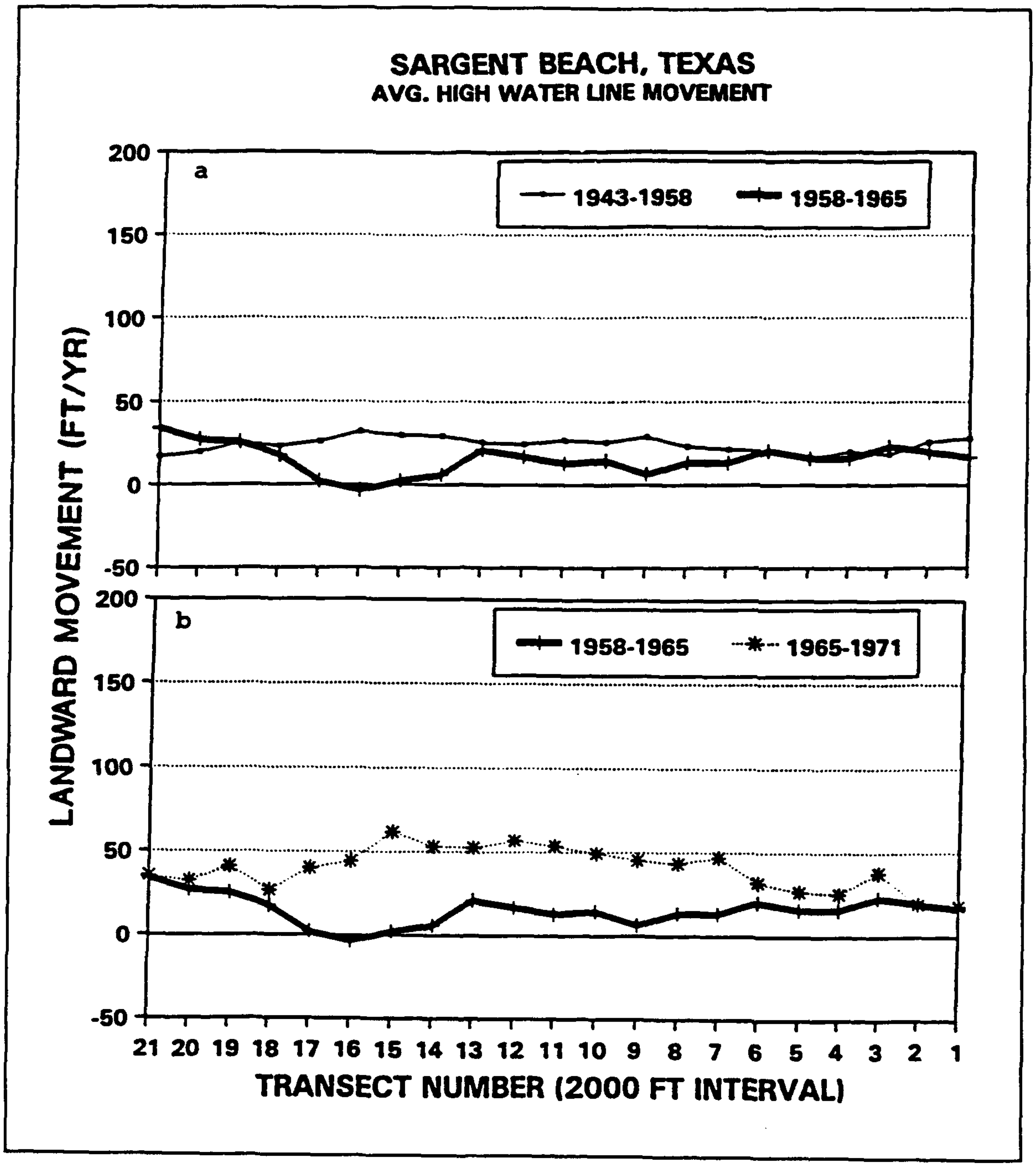



Figure 18. Average high-water line movement (a) from 1943-1958 and 1958-1965, (b) from 1958-1965 and 1965-1971

Comparing the periods between 1965-1971 and 1971-1986 the rates of erosion again slowed (Figure 19a). The spatial pattern during the 15 years between 1971-1986, however remained the same with higher rates between Transects 7 and 16 in the center of the study area. With the man-made closing of McCabe's Cut and the closing of Charpiot's Cut, large changes occurred in the position of the high water line. With the filling of the channel at the entrance to Charpiot's Cut, the shoreline accreted out to the adjacent straight shoreline position (see yellow line on Figure 13). The result was a seaward shoreline movement locally at Transect 11 (Figure 19b). Accompanying this seaward movement at the cut, was a drop in the erosion rate to near zero for all the Transects northeast of Transect 10. In contrast, the Transects southwest of Transect 14 show an erosion rate similar to the previous period. The large increase in the shoreward rate of movement at Transect 18 is a result of the man-made closure of McCabe's Cut. The Cut is now closed, but the beach in front of the former inlet channel is low and allows swash to penetrate further into the backbeach area than on the adjacent transects, moving the high water line landward. The southwestern Transects 20 and 21 have retained the same erosion rate as in the prior period. Maintenance dredging of silt size material from the GIWW has been pumped into the surf zone between the two Cut's during three separate periods (June/July 1988 - 28,9403 yds$^3$; October 1988 - 22,360 yds$^3$; and September 1989 to January 1990 - 133,000 yds$^3$) and may be a factor affecting the constant erosion rate for the 1986-1989 period.

To summarize the temporal changes in erosion rate of the high water line along the study length from Transects 1 to 21 an average value for landward movement rate was calculated for each study time period. Figure 20 shows the average rate of movement and the standard deviation from that rate on a time line along with the times of aerial photography. The values range from a minimum of 15.3 ft/yr between 1958 and 1965 to a maximum of 40.3 ft/yr between 1965 and 1971. The 46 year average rate of 25.5 ft/yr includes all Transects from 1 to 21. From Figure 17 it can be seen that the alongshore variability is notable between the area of the two Cuts and the ends of the study area. Calculation of erosion rates based on alongshore position may be a better way to identify this dynamic beach. The higher maximum shoreline landward migration distances and rates have been measured in the area adjacent and between McCabe's and Charpiot's Cuts and averaged 30.3 ft/yr over the 46 year period and 36.0 ft/yr over the most recent 24 years. Lower maximum landward shoreline movements and rates for the 46 year study were measured northeast of Charpiot's Cut and southwest of McCabe's Cut and averaged 22.8 ft/yr, while the most recent 24 year period averaged 25.0 ft/yr.

Predicting actual future shoreline retreat positions is difficult, owing to the fact that the shoreline landward retreat has not been constant over the study period. The frequency and intensity of storms affecting the area is probably a major factor in the retreat rate which is difficult to predict. An estimate of the future shoreline positions based on the average erosion rates for the northeast end of the study area has been made for two and five years into the future and are 45.7 and 114.2 ft landward of the 1989 shoreline respectively. The shoreline position between the two Cuts has been estimated for two and five years into the future and are 60.7 and 151.7 ft respectively landward of the 1989 shoreline. At the average erosion rate of 22.8 ft/yr for the shoreline northeast of Charpiot's Cut, with an average island width of 700 ft it would take 30.7 years to erode the shoreline back to the GIWW. Based on the average 30.3 ft/yr erosion rate between the two Cut's, and average island width of 850 ft, it would take approximately 28 years for the shoreline to reach the

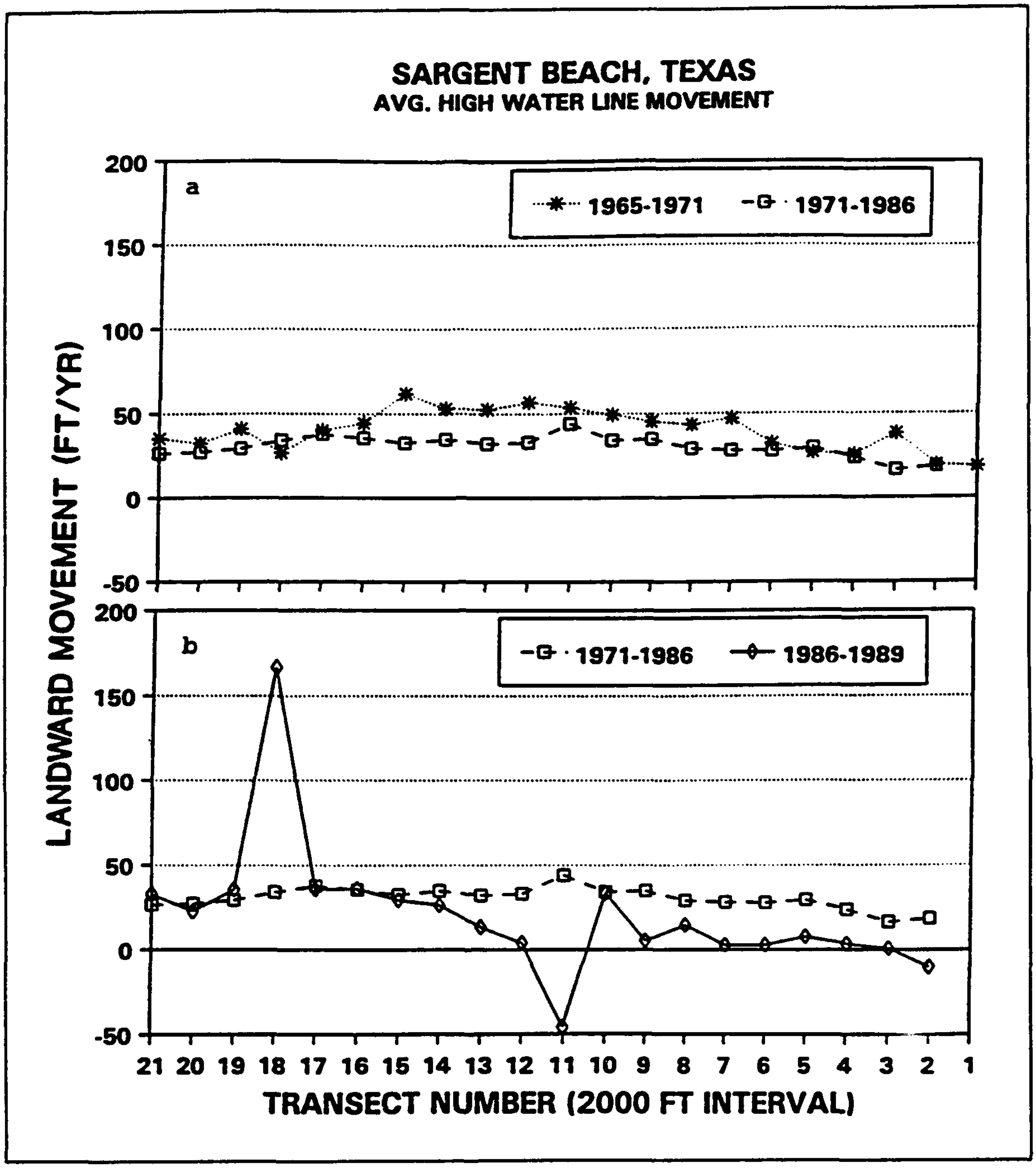



Figure 19. Average high-water line movement (a) from 1965-1971 and 1971-1986, (b) from 1971-1986 and 1986-1989

GIWW. It is anticipated that breaching would occur earlier in the areas that are low, associated with the former cuts, or where ponds are located on the barrier island.

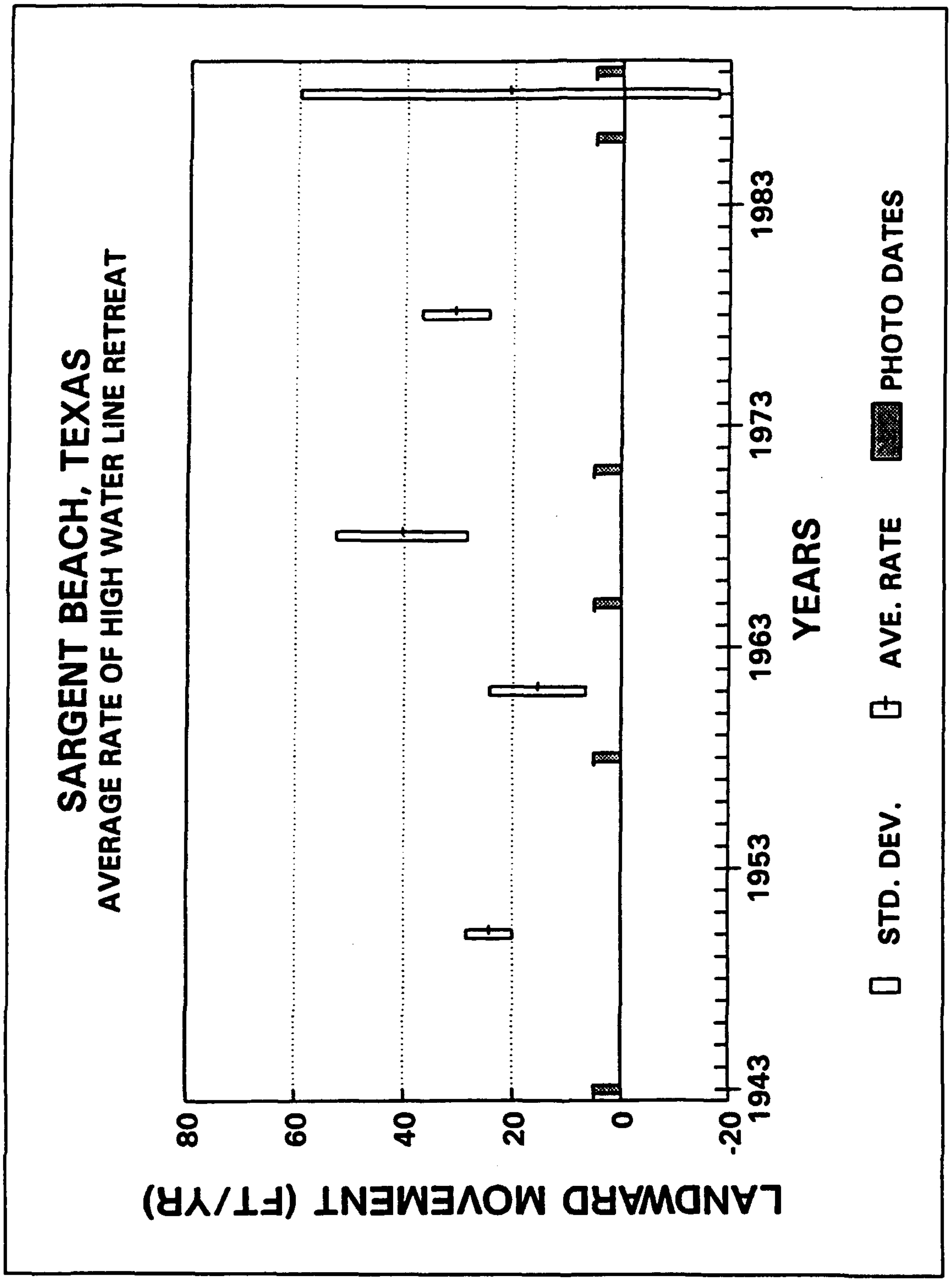



Figure 20. Average rate of high-water line erosion between each sampling period with standard deviation

## Sediment Analysis

The composition of the sediment along Sargent Beach is a factor in the large erosion rates observed. Surface grab samples and hand auger cores were collected on a field inspection trip on 19 and 20 November 1990. Samples were collected at five sites along shore normal transects close to known survey markers along the study area (Figure 21). Surface sediment was collected in the vicinity of the overwash fan on the back beach, at the high water line, mid-tide area and at the area of low tide (Table 5). Hand auger cores of around six feet in length and 3-in.-diam aluminum pipe cores were also collected at three of the sites to supplement hand auger cores collected by the Galveston District. Due to difficulties with penetration of pounding 3-in.-diam pipe into the prevalent shell hash and stiff clayey silt, an auger core method was used. As the corer was filled it was lifted to the surface after the depth was noted on the handle. The sample was placed in a pre-split length of 1-1½-in.-diam PVC pipe. When the pre-cut length was filled with core sections, it was taped together. Standard laboratory core description procedures were used during lab analysis. Care was taken when loading the core tube to match the position in the core measured on a tape with the actual depth as measured on the auger handle. In this manner a accurate core could be constructed.

The cores were untaped and split open at the laboratory, where the core was described and logged (Appendix A). The surface samples were sieved on a sonic sifter and analyzed using ISAP (Interactive Sediment Analysis Program) computer program. Statistical data on the grab samples are listed in Table 6, with a complete list of the output in Appendix B. A composite sample was calculated by mathematically combining the berm crest, mid-tide and low tide samples together, in order to reduce the cross-shore variability. These values are also given on Table 6 and in Appendix B. The overwash samples were not included in the composite calculation since they are lag deposits from extreme events that have been winnowed by wind transport. The active beach between the berm crest (high tide area), mid-tide, and low tide gives a more representative picture to characterize the beach sediment distribution.

### Cedar Lake area beach sediments

The Cedar Lake sediment transect located near survey marker S-29 contained surface samples of the berm crest, mid-tide area and the low-tide zone. The barrier beach was narrow at this point, in close proximity to Cedar Lake, and no distinct overwash fan was present. The back shore area sloping into Cedar Lake was moderately well vegetated. A hand auger core of 1 ½" diameter was collected at the berm crest while 3" diameter aluminum pipe was pounded in at the mid-tide and low-tide zones. Due to problems with penetration into the surface shell hash, this procedure was discontinued at the other transects. The auger core method performed well.

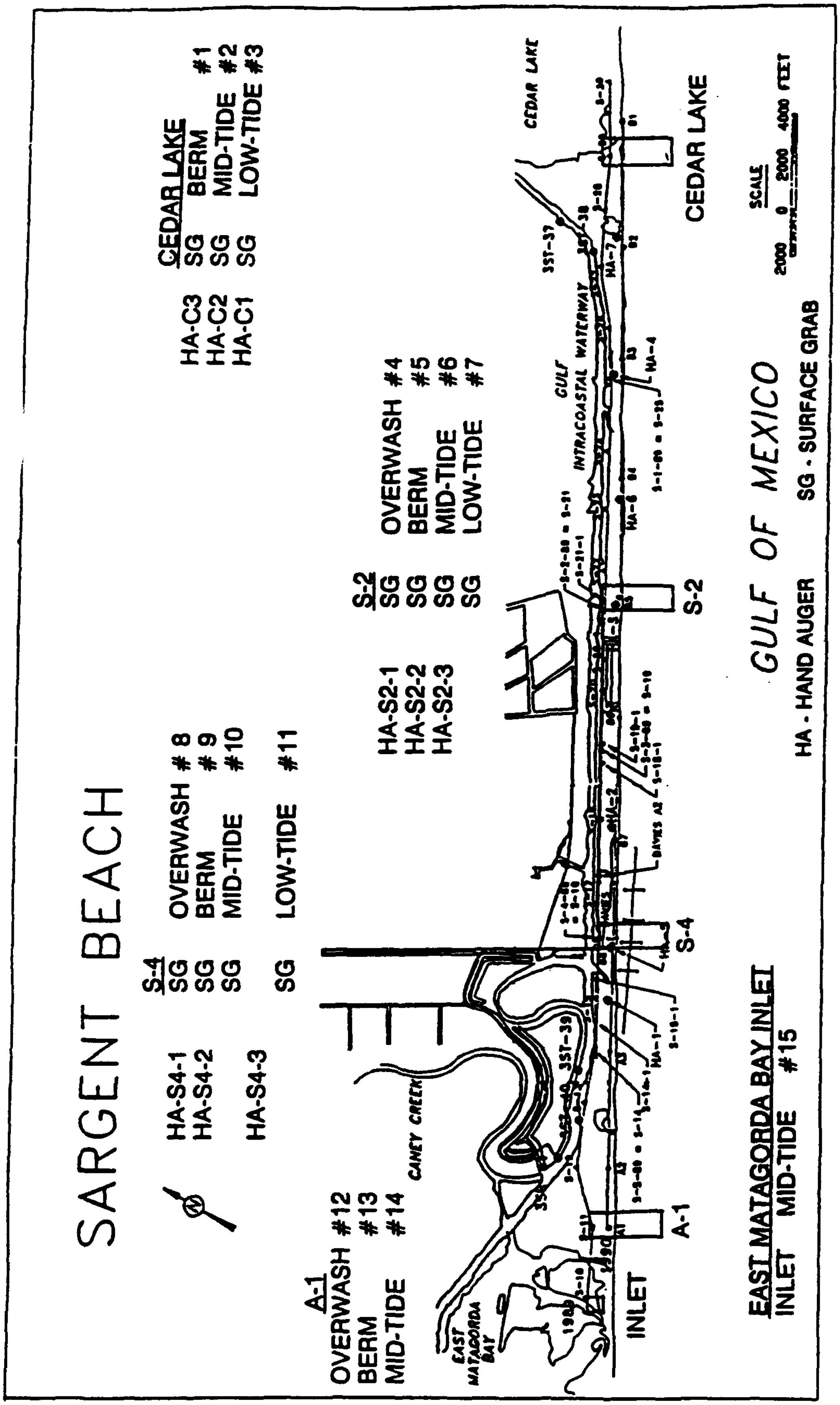



Figure 21. Sediment collection locations

**Table 5**
**Sediment Sample Type and Location**

| Sample No. | Type | Location on Transect | Core Length |
|---|---|---|---|
| **Cedar Lake** | | | |
| 1 | Surface Grab | Berm | |
| C-3 | Hand Auger Core | Berm Crest | 1.05 ft. |
| 2 | Surface Grab | Mid-tide | |
| C-2 | 3" diam. Al Core | Mid-tide | 0.92 ft. |
| 3 | Surface Grab | Low-tide | |
| C-1 | 3" diam. Al Core | Low-tide | 1.23 ft. |
| **S-2 (near S-21-1)** | | | |
| 4 | Surface grab | Overwash Fan | |
| HA-S2-1 | Hand Auger Core | Overwash Fan | 6.43 ft. |
| 5 | Surface Grab | Berm Crest | |
| HA-S2-2 | Hand Auger Core | Berm Crest | 6.39 ft. |
| 6 | Surface Grab | Mid-tide | |
| HA-S2-3 | Hand Auger Core | Mid-tide | 6.40 ft. |
| S2 | Aluminum Core (Not used) | Mid-tide | 1.76 ft. |
| 7 | Surface Grab | Low-tide | |
| S2 | Aluminum Core (Not used) | Mid/low-tide | 1.97 ft. |
| **S-4** | | | |
| 8 | Surface Grab | Overwash Fan | |
| HA-S4-1 | Hand Auger Core | Overwash Fan | 6.37 ft. |
| 9 | Surface Grab | Berm Crest | |
| HA-S4-2 | Hand Auger Core | Berm Crest | 6.40 ft. |
| 10 | Surface Grab | Mid-tide | |
| HA-S4-3 | Hand Auger Core | Mid/low-tide | 3.20 ft. |
| 11 | Surface Grab | Low-tide | |
| **S-11 (A-1)** | | | |
| 12 | Surface Grab | Overwash Fan | |
| 13 | Surface Grab | Berm Crest | |
| 14 | Surface Grab | Mid-tide | |
| AIS&C | Surface Grab | Low-tide | |
| **E. Matagorda Bay Inlet (northeast side)** | | | |
| 15 | Surface Grab | Mid-tide | |

The Cedar Lake surface samples were all characterized with large quantities of shell hash material. The sediment distribution curves show a coarse peak around 4.0 mm (-2.0 $\phi$) which was composed of this shell material (Figure 22). The quartz beach sand material that made up the rest of the samples were less than 0.5 mm (1.0 $\phi$). Because of this high shell content the mean values are skewed to the coarser sizes. The average sand sizes are better predicted by using the median values. The composite median value, characteristic of the

**Table 6**
**Sediment Statistics**

| Sample Name | Median (Folk) PHI | Median (Folk) mm | Median (Moment) PHI | Median (Moment) mm | St. Deviation (Moment) PHI | Sample No |
|---|---|---|---|---|---|---|
| **CEDAR LAKES** | | | | | | |
| BERM | 2.23 | 0.21 | 1.82 | 0.28 | 1.39 | 1 |
| MID-TIDE | 2.56 | 0.17 | 2.46 | 0.18 | 0.78 | 2 |
| LOW-TIDE | 2.95 | 0.13 | 2.51 | 0.18 | 1.31 | 3 |
| COMPOSITE | 2.56 | 0.17 | 2.30 | 0.20 | 1.18 | CLCOMP |
| **S-2** | | | | | | |
| OVERWASH | 2.01 | 0.25 | 1.22 | 0.43 | 1.67 | 4 |
| BERM | 2.37 | 0.19 | 2.30 | 0.20 | 0.68 | 5 |
| MID-TIDE | 0.87 | 0.55 | 0.84 | 0.56 | 1.71 | 6 |
| LOW-TIDE | 0.89 | 0.54 | 0.79 | 0.58 | 2.00 | 7 |
| LOW-TIDE CORE (-75 cm) | | | 6.02 | 0.016 | 2.39 | HA-S2-3* |
| COMPOSITE (Composite contains Berm, Mid-Tide, Low-Tide) | 2.09 | 0.24 | 1.13 | 0.46 | 1.78 | S-2COMP2 |
| **S-4** | | | | | | |
| OVERWASH | 2.15 | 0.23 | 1.96 | 0.26 | 0.87 | 8 |
| BERM CREST | 2.37 | 0.19 | 2.38 | 0.19 | 0.40 | 9 |
| MID-TIDE | 0.68 | 0.63 | 0.34 | 0.79 | 1.93 | 10 |
| LOW-TIDE | 2.26 | 0.21 | 1.75 | 0.30 | 1.43 | 11 |
| LOW-TIDE CORE (-85 cm) | | | 7.81 | 0.005 | 2.16 | HA-S4-3* |
| COMPOSITE (Composite contains Berm, Mid-Tide, Low-Tide) | 2.18 | 0.22 | 1.48 | 0.36 | 1.66 | S-4COMP2 |
| **A-1** | | | | | | |
| OVERWASH | 2.35 | 0.20 | 2.28 | 0.21 | 0.61 | 12 |
| BERM CREST | 2.34 | 0.20 | 2.37 | 0.19 | 0.49 | 13 |
| MID-TIDE | 2.40 | 0.19 | 2.31 | 0.20 | 0.72 | 14 |
| LOW-TIDE | 4.51 | 0.04 | 5.26 | 0.026 | 2.55 | A1-S&C* |
| COMPOSITE (Composite contains Berm, Mid-Tide) | 2.37 | 0.19 | 2.34 | 0.20 | 0.61 | A-1COMP2 |
| COMPOSITE (Composite contains Berm, Mid-Tide) | 2.82 | 0.14 | 4.03 | 0.006 | 2.56 | A-1COMP3 |
| **E. MATAGORDA BAY INLET N. SIDE** | | | | | | |
| MID-TIDE | 2.08 | 0.24 | 1.56 | 0.34 | 1.43 | 15 |

Note: * grain size measured by sieve and pipette method.

sand fraction was 0.17 mm (2.56 ϕ), in the fine sand range. The mean, more influenced by the shell was 0.20 mm (2.30 ϕ). No clayey-silt was visible on the beach profile, and the short cores reveled that at least to -1.05 ft (-0.32 m) in depth no silt material was present at the berm crest. This area was the thickest deposits of sand on all profiles. The finer material was very close to the surface at -0.59 ft (-0.18 m) below the surface in the low tide zone core.

### Charpiot's Cut area beach sediments

Further to the southwest at transect S-2, located up coast from Charpiot's Cut, a large overwash fan was present in the back beach area. Surface grab samples and hand auger cores were taken in approximately the center of the overwash fan, on the berm crest, at the mid-tide location, with only a grab sample in the low tide zone. Again large amounts of shell hash material composed of whole and broken shell material was present, particularly as a lag deposit in the overwash fan and on the mid and lower foreshore.

The surface sediment distribution curves show the poorly sorted samples with the coarse peak around 4.0 mm (-2.0 ϕ) again being composed of all shell material. The main peak around 0.21 mm (2.25 ϕ) was composed of quartz sand material but small shell were also present here (Figure 23). Only the berm crest sample was lacking the coarser shell material. The composite median value for this transect was 0.24 mm (2.09 ϕ). The mean again reflected the high shell hash content found along this transect, with a coarser 0.46 mm (1.13 ϕ), in the medium sand range. From the analysis of the longer cores at this transect, it was found that the top of the peat/clayey-silt layer was at -1.83 ft (-0.56 m) in the overwash fan, -2.92 ft (-0.89 m) at the berm crest, and at a shallow -1.02 ft (-0.31 m) on the mid-foreshore. Again no clayey-silt material was visible on the surface of the profile. Pipette analysis of this fine grained sediment from around -2.79 ft (-0.75 m) in core HA-S2-3 (mid-foreshore) showed a mean of 0.016 mm (5.99 ϕ), with 39 percent fine sand, 32 percent clay, and 29 percent silt.

### McCabe's Cut area sediments

Transect S-4 was chosen near the base of the eroding highway (FM 457), to examine the sediment distribution in the area of visible high erosion. A well-developed overwash fan was again present at this transect. Samples and cores were collected on the overwash fan and at the poorly defined berm crest. Surface grab samples were collected at mid-tide and in the low tide swash zone. A hand auger core was taken on the lower foreshore between the mid- and low tide grab samples. This was done to measure the thin sand veneer over the clayey-silt layer that outcropped in the lower foreshore. This layer formed a wave cut terrace with a vertical scarp at the low water line.

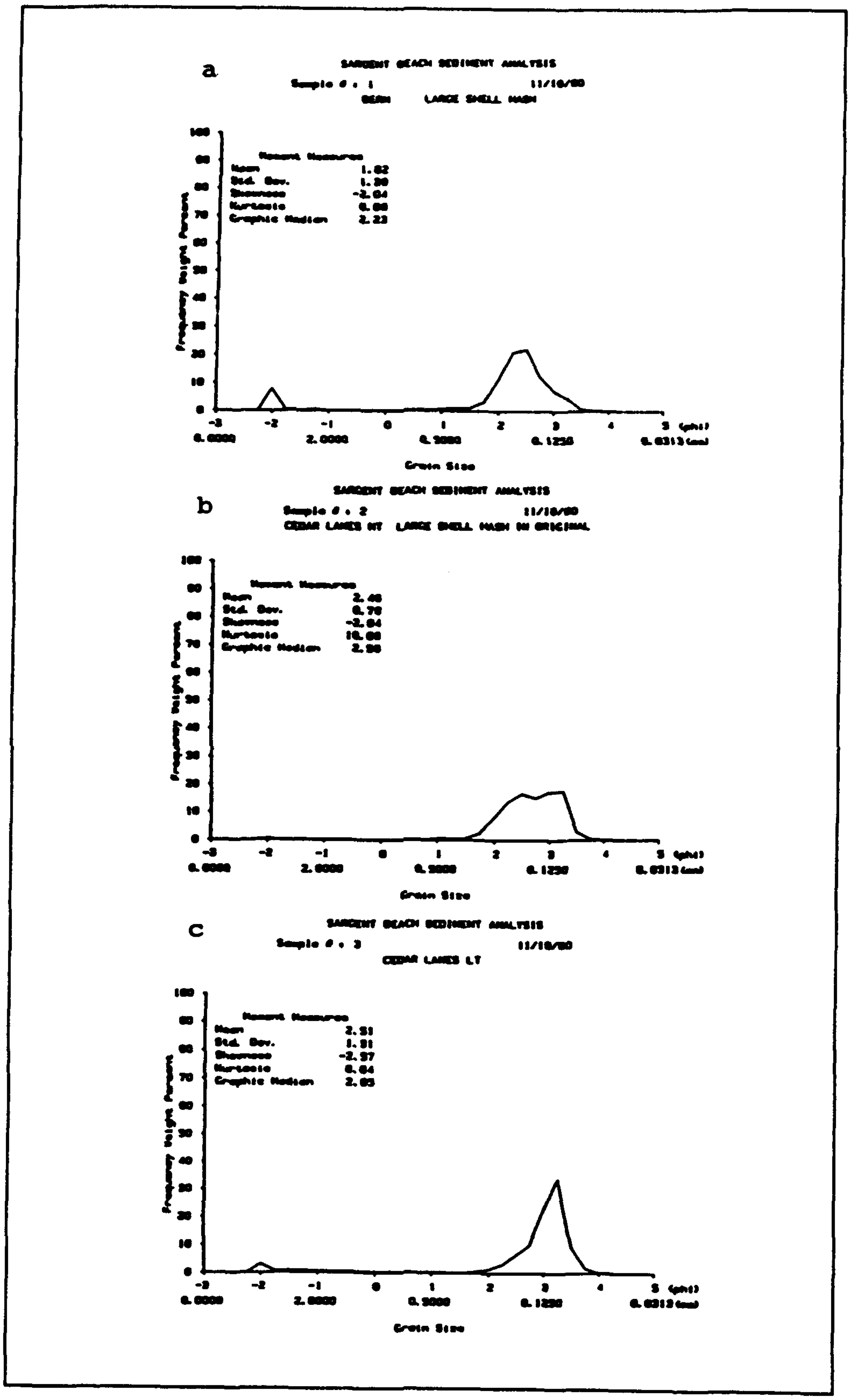


Figure 22. Surface sediment grain-size distributions of the Cedar Lake samples, (a) berm crest, (b) mid-tide, and (c) low tide

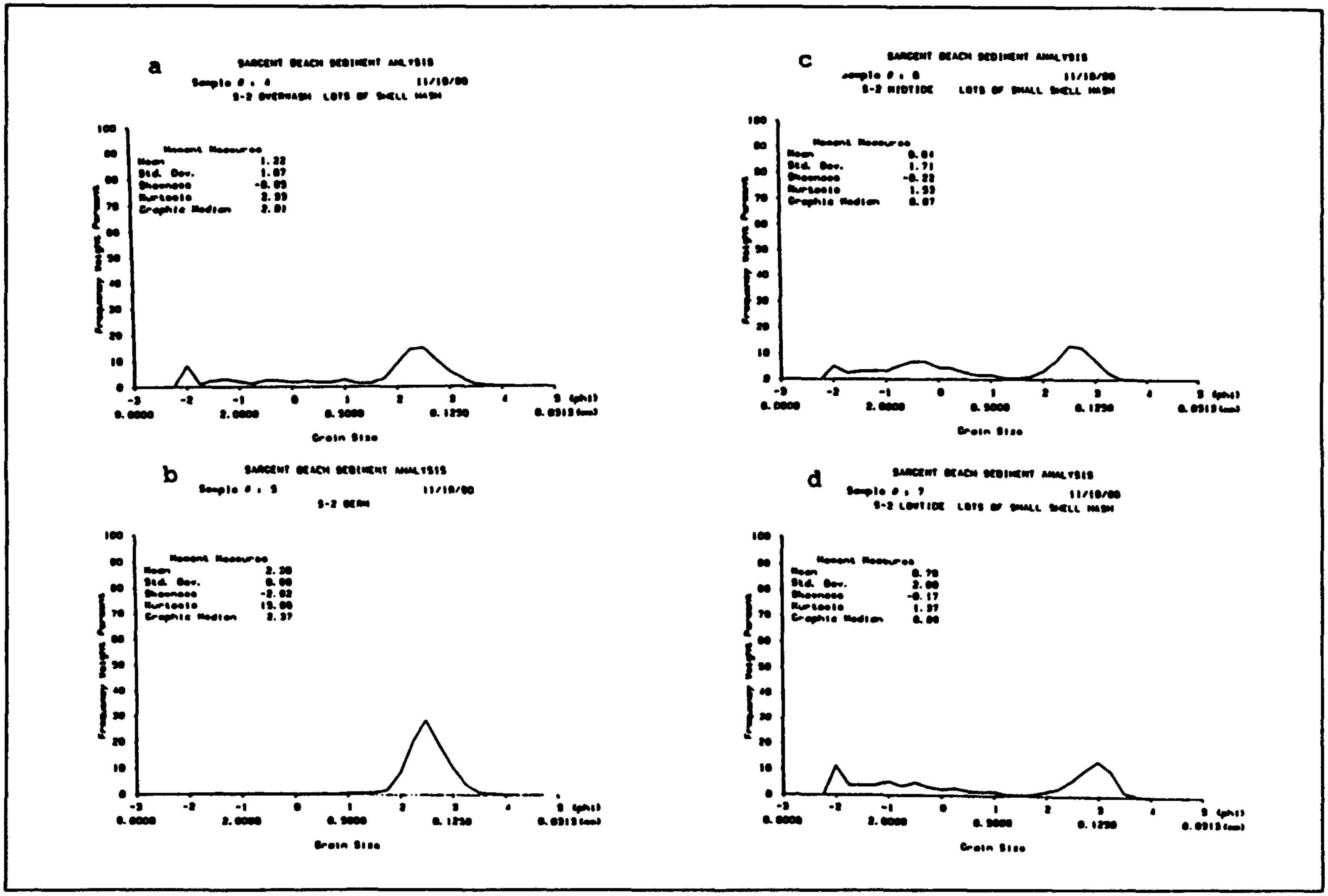



Figure 23. Surface sediment grain size distributions of the S-2 samples, (a) overwash, (b) berm crest, (c) mid-tide, and (d) low tide

The sediment grain size distributions of each surface grab sample (Figure 24) show a small amount of shell material on the overwash fan, little shell material at the berm crest and large amounts of small shell hash in the mid- and low tide areas. The low tide sand sample was collected from one of the pockets of sand between the clayey-silt terraces. Again the main sand peak was found around 0.21 mm (2.25 ϕ). The composite median for Transect S-4 was similar to Transect S-2, with a 0.22 mm (2.18 ϕ) value. The mean again reflected the coarse shell material component found on this transect with a value of 0.36 mm (1.48 ϕ), which is in the coarse sand range (Wentworth Classification).

The sand thickness on the overwash fan at S-4 was similar to the overwash deposit at S-2, but where there was a sharp break in the sand/clayey-silt interface at S-2, in was a gradual increase in finer material at S-4. The depth where clayey-silt becomes prominent was between -1.38 to -1.87 ft (-0.42 to -0.57 m). On the berm crest the sand/clayey-silt interface was gradational around -1.97 ft (-0.6 m), where it was mixed with roots, indicating a possible old marsh surface. The foreshore core had very little sand (only around 0.20 ft (0.06 m) above the silty-clay beds. Pipette analysis of this fine grained sediment from around -2.79 ft (-0.85 m) in core HA-S4-3 showed a mean of 0.005 mm (7.81 ϕ), with 62% clay, 33% silt and 5% fine sand. Analysis of the clay sample by x-ray diffraction in bulk sample indicated weak clay mineral peaks with quartz having the strongest peaks. A 24 Angstrom (A) peak was found indicating that mixed-layer clays were present although quartz fragments were common. Further analysis of oriented samples indicated that kaolinite (7A) and illite (10A) had weak but distinct peaks along with mixed-layer clays (14A+). After glycolation smectite was also identified with shifting of the (14A+) peaks.

### East Matagorda Bay area beach/inlet sediments

No cores were collected at the southwestern end of the study area in the vicinity of A-1 (S-11), but four surface grab samples were collected. The area of overwash was extensive with little to no relief on the dune. The vegetation line was distinct without any dune development. A sample was collected in the central area of sheet overwash, on the berm crest, at mid-tide and at the low tide area. Sand was present on the profile out to the low tide wash zone where the clayey-silt bed was exposed into the nearshore. The low tide sample containing 42% sand, 31% silt and 27% clay was collected in the low tide terrace and was analyzed for size by sieve and pipette. The shell content was much less in these surface samples and they were composed of mostly quartz sand. The grain size distributions show a well sorted fine sand uniformly across the transect up until the low tide area (Figure 25). Without the bimodal shell material or the fine low tide sample the composite median value of 0.19 mm (2.37 ϕ) is close to the mean of 0.20 mm (2.34 ϕ). This median value is similar to the Cedar Lake composite.

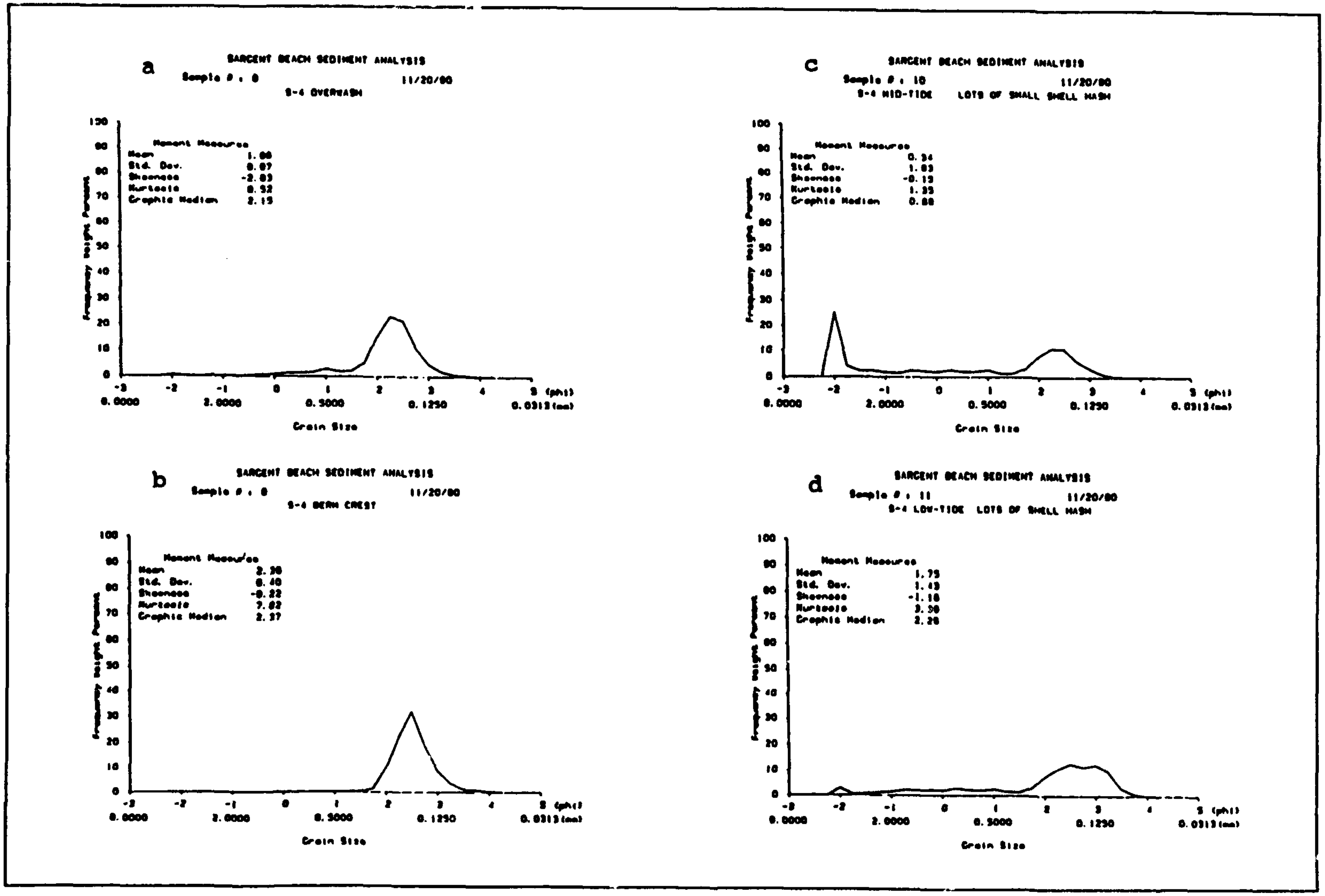



Figure 24. Surface sediment grain size distributions of the S-4 samples, (a) overwash, (b) berm crest, (c) mid-tide, and (d) low tide

A sediment sample was collected on the east side of unnamed inlet to East Matagorda Bay at the extreme southwestern end of the study area. This one sample contained some shell material and was bimodal. The grain size distribution has the same general shape as the other bimodal samples along this coast (Figure 26). With the shell content creating this bimodality, the mean at 0.34 mm (1.13 $\phi$) is coarser than the median of 0.24 mm (2.09 $\phi$).

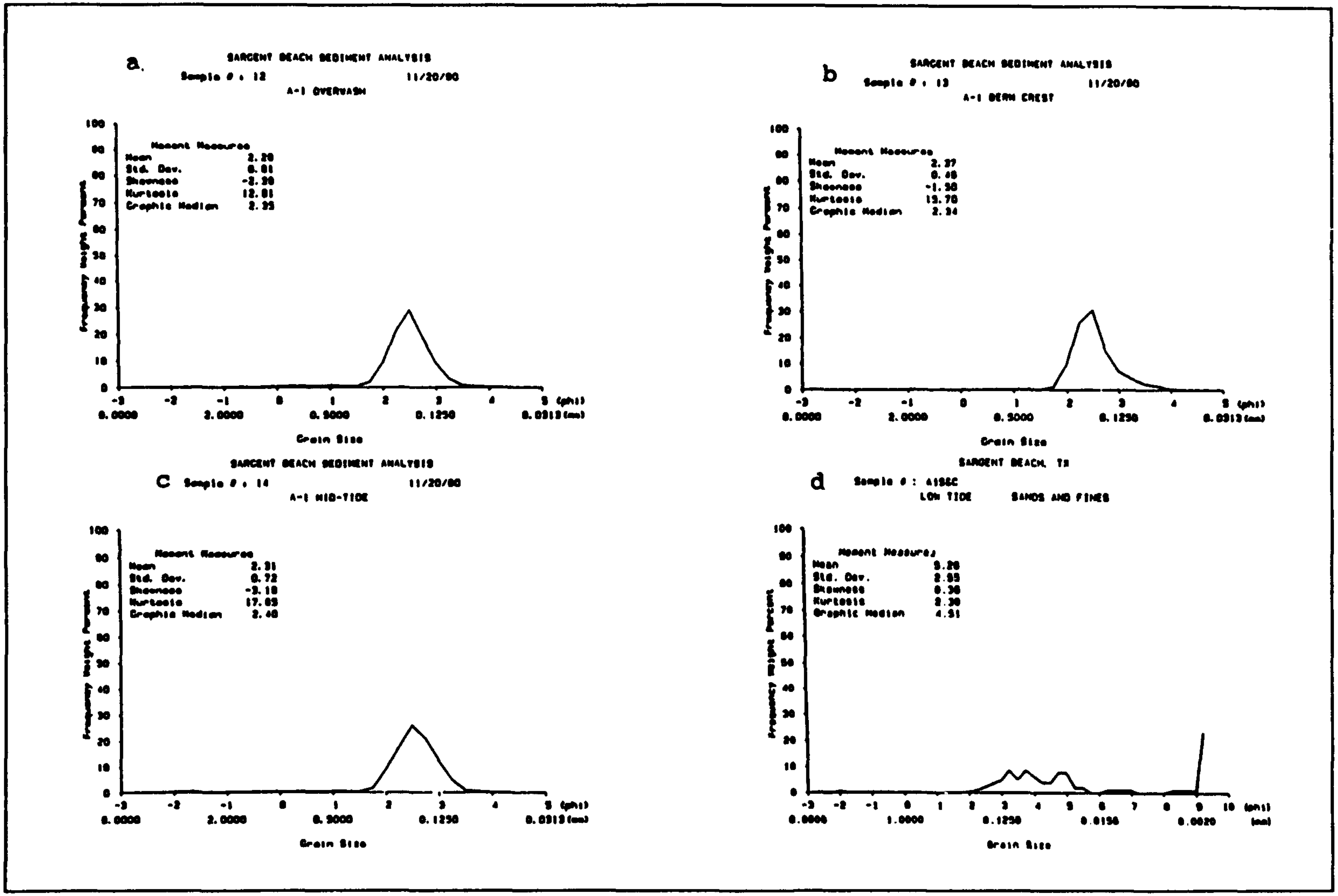



Figure 25. Surface sediment grain size distributions of the A-1 or S-11 samples, (a) overwash, (b) berm crest, (c) mid-tide, and (d) low tide. Note expanded size range on plot of low tide sample

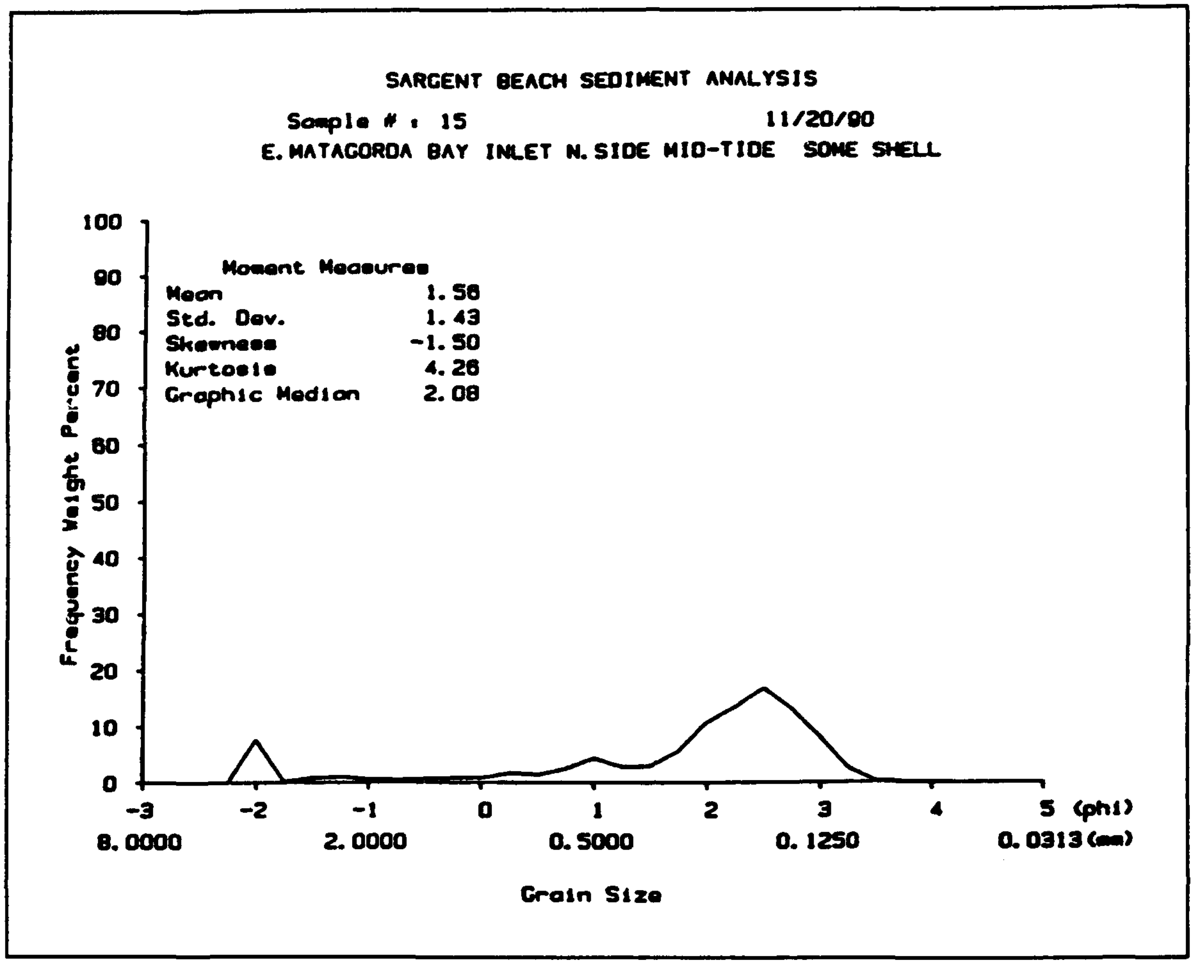



Figure 26. Surface sediment grain size distributions of the mid-tide at the northeast side of East Matagorda Bay Inlet

# 4 Mechanisms of Erosion at Sargent Beach, Texas

## Introduction

Sargent Beach is located south of Freeport, Texas, on the western flanks of the Brazos River Delta. The beach fronts a deltaic headland area between Follets Island and the Matagorda Peninsula. The tidal regime in this coastal area is microtidal with a mean range of less than a meter. The dominant direction of longshore sediment transport is to the south (McGowen et al. 1977). The Texas coast is characterized as storm dominated (Snedden et al. 1988; Davis and Hayes 1985).

The primary sediment source to this beach system was the Colorado-Brazos River fluvial-delta complex (Weiss and Wilkinson 1988), including the Brazos River, Oyster and Caney Creek, and the San Bernard River (Figure 27). Climatically reduced discharge and sediment yield, and more recently flood control structures built along these rivers have effectively blocked new sediments from entering the nearshore system, changing this coastal from progradational to erosional (Morton and Nummedal 1982; Fields, Stauble and Trawle, in press).

Sargent Beach is located on the fastest eroding shoreline in Texas. Since the mid 1800's Sargent beach has retreated over 520 m, or an average of slightly more than 4 m/yr (Morton and Piper 1975). In this area, short term rates of erosion as high as 12 m/yr have been documented by the same researchers.

## The Holocene History of the Sargent Beach Area

The inner shelf area of the Gulf of Mexico in the vicinity of Sargent Beach has been characterized by several researchers (Weiss and Wilkinson 1988: Morton and Piper 1975). In the Sargent beach nearshore area the inner shelf is covered by a shelly gravel. The gravel clasts are comprised primarily of whole and fragmented shells derived from *Rangia* sp. and *Crassostrea Virginica*

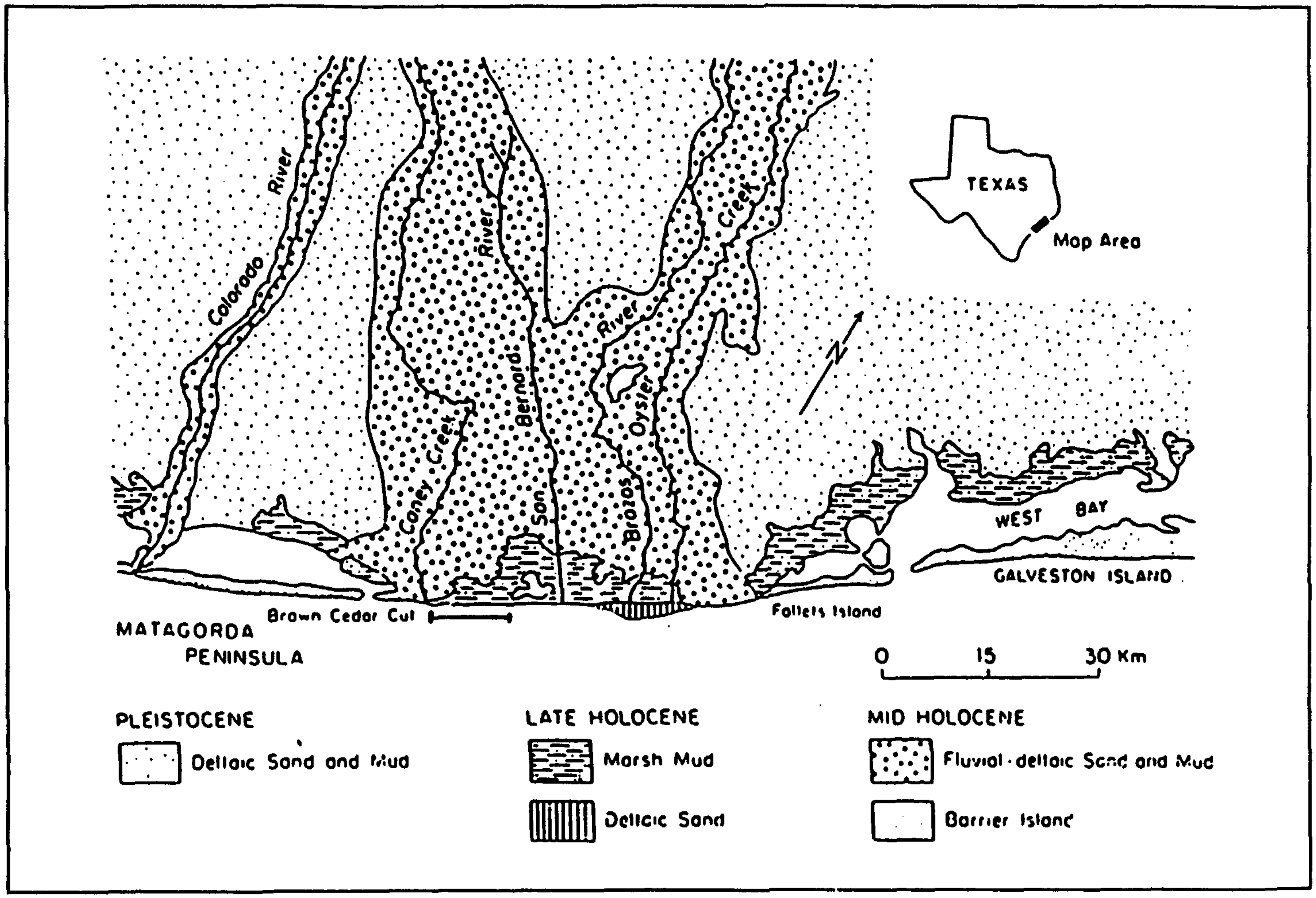



Figure 27. Generalized sediment map of study area. The bracket area between the San Bernard River and Caney Creek was the locus of this study

(Morton and Winker 1979). These fauna are indigenous to brackish and freshwater environments. This lithified unit extends offshore as much as 20 km. A holocene age marsh lies over this unit (Weiss and Wilkinson 1988).

Approximately 4,000 years ago a continuous sandy barrier was located seaward of the Sargent Beach shoreline area. The late Holocene sea level rise (Wilkinson and Basse 1978) caused the beach sands to erode and the Brazos River delta complex was transgressed. As the shoreline retreated, the transgressed environments probably included fluvial, deltaic and estuarine environments. As the Sargent Beach area continued to erode, these environments were exposed on the beachface. At the present, marsh bluffs comprise a large percentage of the subaerial beach system (Figure 28). Low pillars of marsh material exposed in the nearshore region during the side-scan sonar operation (Levin 1991) suggest that this environment extended a significant distance offshore.

Figure 28. Ground photograph of Sargent Beach, Texas, southwest of the eroded end of Highway FM 457 looking to the northeast. Note the low bluffs of marsh outcroppings on the beachface

## The Present Status of Sargent Beach

Sargent Beach is not a "beach" as would be typically envisioned, but is comprised primarily of river floodplain muds and marsh overlain by a thin veneer of shelly gravels and fine sand. The shelly debris are derived from the exposed inner-shelf area (Morton and Winker 1979; Morton and Nummedal

1981). Low elevation bluffs of hardened, semi-cohesive lagoonal muds approximately a meter high and several meters in width are prevalent on the beach face (Figure 28). It is assumed that these bluffs are more resistant to erosion than beaches dominated by sand. The fine-grained prominents are separated by evenly spaced, low swales that are oriented normal to the beach face. The swale widths are approximately equal to the individual bluff widths (Figure 29).

## Objectives

Erosion at Sargent Beach cannot be described or analyzed using classic scenarios that treat beaches as non-cohesive accumulations of sand size material. In the case of Sargent Beach the beach face is dominated by fine-grained semi-cohesive sediments. Shoreline retreat in this area is governed by mechanics of erosion that differ considerably from those that effect sand transport. A literature review has been conducted to gain insight into the processes occurring on the Sargent Beach area. The objectives of this review are listed below.

*a.* Ascertain whether a fine-grained beach would erode faster than a sandy beach.

*b.* Determine whether the beach profile can recover following a storm event. If not, do storms accelerate the rate of erosion?

*c.* Is the rate of erosion concentrated above a certain elevation? Is the nearshore profile significantly different than other eroding shorelines?

## The Profile of a Fine-Grained Beach Face

Steep bank profiles characterize shorelines with a sediment component that is primarily fine-grained (Kilgour et al. 1976; Davidson-Arnott and Askin 1980; Ginsberg and Gerardo 1990; Kamphus 1990 and others). The cohesive nature of clays and overconsolidated tills allows steep banks to form at the sediment-water interface. The steeper profile is confined to the upper intertidal beach zone. A more gently sloping, concave profile will occur in the lower and inner shore portions of the beach profile/shoreface envelope (Kamphus 1990). Overall, during a transgression of a shoreline dominated by bluffs of fine-grained or overconsolidated sediments, the upper portion of the profile will be steeper than if it were a sandy shoreline (Kilgour et al. 1976).

The rate of shoreface retreat may be dependent upon the regional stratigraphy. Apriore, it has been concluded that the fine-grained bluffs would erode slower than a commensurate sandy coast. However, the rate of erosion in the upper segment of the beach profile is independent of the maximum depth of erosion that is controlled by the wave base. For engineering

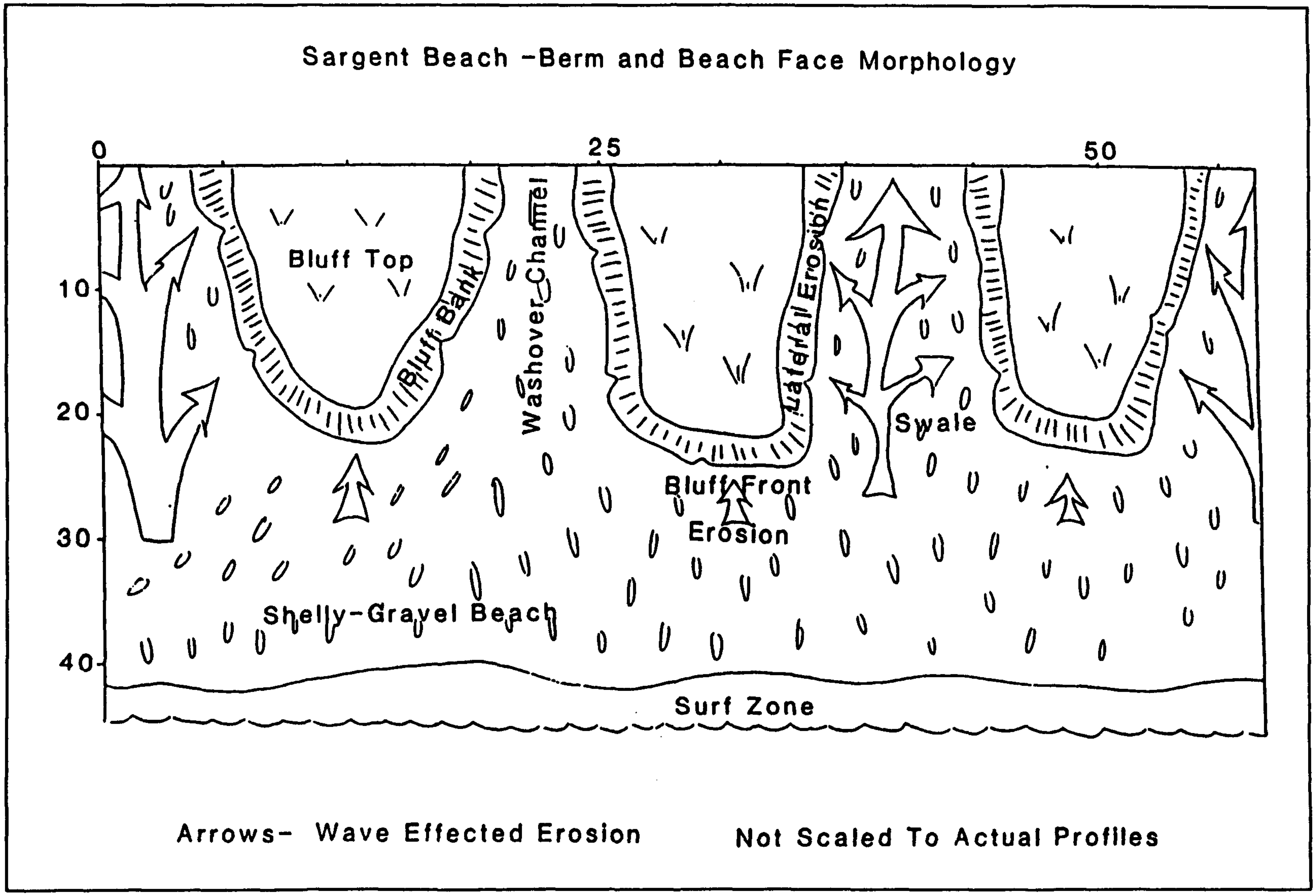



Figure 29. Diagram of the berm and beachface morphology at Sargent Beach. Low bluffs are separated by swales

considerations it should be noted that shoreface retreat will probably proceed landward in accordance with a modified Bruun rule regardless of the lithology (Bruun 1988).

# Mechanisms of Erosion at Sargent Beach, Texas

There are a variety of processes contributing to the erosion of fine-grained bluffs cropping out on Sargent Beach. The combination of stratigraphy, sedimentology and a myriad of mechanical processes all contribute to local shoreline retreat.

## Bluff sedimentology and stratigraphy

Sedimentologically, the bluffs are comprised of a poorly sorted mix of sandy, silty, clay. The clays are the matrix that bind the subordinate sediments in place. The sediments in the upper portion of the bluffs are also anchored by a moderately dense root system. The marsh and deltaic facies represented by this sedimentology are deposited in quiet water, low energy environments. Periodically, washovers of the sandy beach deposits over the backbarrier environment caused the sand lens to be deposited over the predominantly fine grained strata.

## Bluff erosion

The erosion of the protruding bluffs is accomplished by a variety of mechanical means. Due to the limited tidal range, waves are concentrated on a small section of the beach face (Pethick 1984). Waves breaking upon the beach propel the shell gravel on the beach into the exposed bluffs. The resulting abrasion removes material from the bluff face (Davidson-Arnott and Askin 1980; Sunamura 1977; Kamphus 1990).

Abrasion of the lower section of the bluff by blasting it with sands and gravels causes undercutting (Figure 30). This phenomena was observed along the northern shore of western Lake Erie by Kilgour et al. (1976), where the overconsolidated bluffs were fronted by a narrow beach. Beach sands were incessantly worked against the bluff toe. Eventually, the bluff became undermined and a block of the consolidated sediments failed and fell to the beach. A similar phenomena probably occurs at Sargent Beach (Figure 30).

Slope failure may also be induced by cyclic loading and unloading at the bluff face. The addition and removal of compressive forces by the uprush and backwash of waves reduces the compressive strength of cohesive soils (Sunanura 1977; Vallejo 1980) causing liquefaction (Davidson-Arnott and Askin 1980). The pumping of waves against the Sargent beach bluff nodes weakens the sediments and causes block failure.

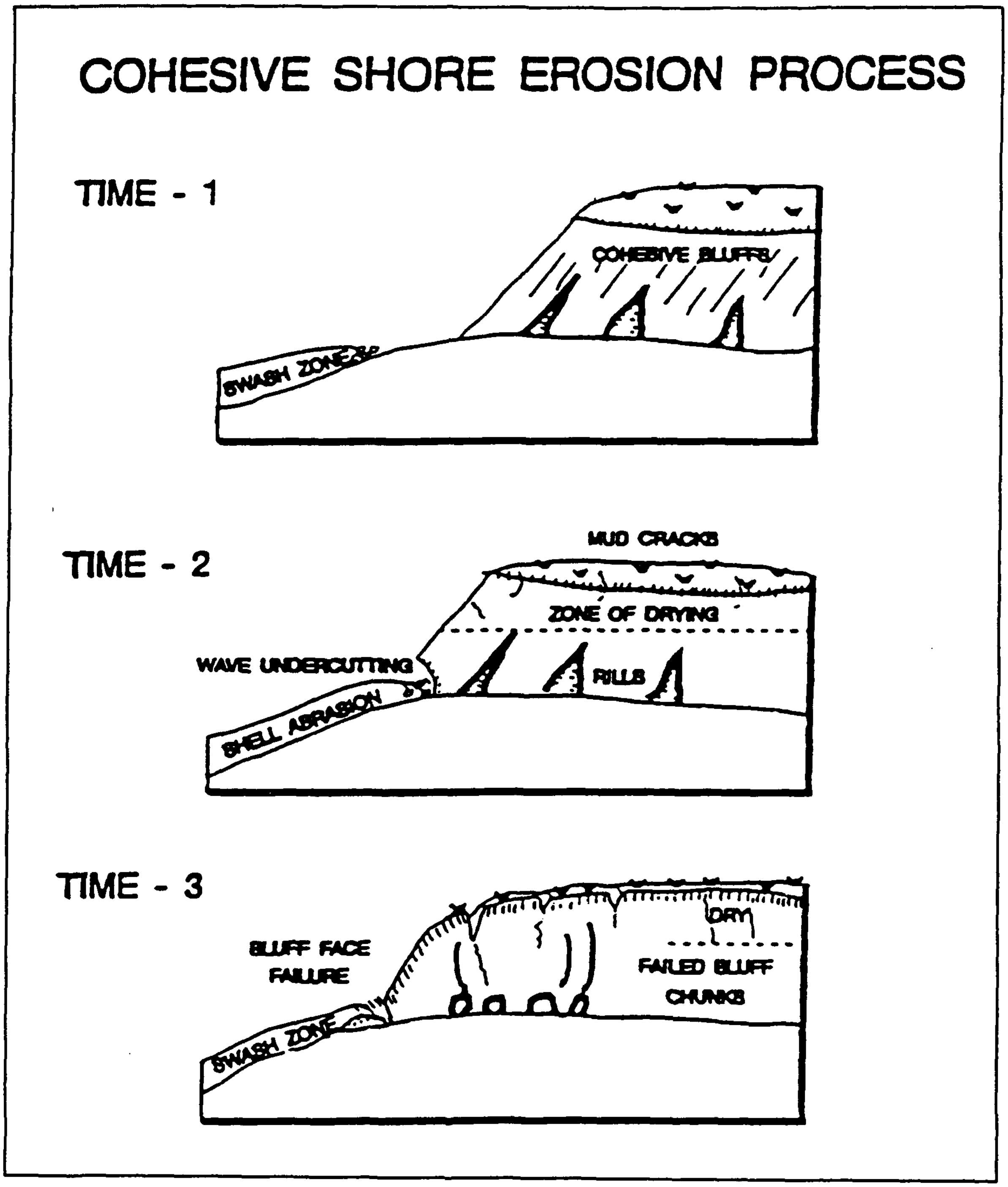



Figure 30. Scenario for bluff failure as at Sargent Beach

The periodicity of the bluff and swales occurring along Sargent beach is difficult to explain (Figure 3). On the banks of the Bahia Blanca Estuary in Argentina a similar occurrence of "erosional cusps" has been documented (Ginsberg and Gerardo 1990). Here, waves undercut steeply sloping fine-grained banks, eventually causing the blocks to rotate and fail in a "cusp-like" configuration. The slope failure is the result of mechanical fatigue of the lower bank caused by small waves and boat wakes.

On a sandy beach, erosion occurs predominantly at the beach face. At Sargent Beach the swales accelerate the beach erosion process. The swales cause more surface area of the finer grained bluffs to be exposed. During intensified wave attack, the swales concentrate the wave bore and intensify the erosive force of the shell gravel as it is hurled against the bluff walls (Figure 29). Through this process, the beach face is removed by lateral erosion.

## The Effects of Subaerial Exposure on Bluff Erosion Rates

The amount of sediment eroded from an exposed marsh by rainfall has been described as insignificant (Letzsch and Frey 1980). However, by removing moisture from cohesive sediments fine grained material may be more easily eroded. Drying cohesive sediments frequently exhibit shrinkage cracks (Reineck and Singh 1980). Mud cracks can occur in a variety of settings and salinities (Plummer and Gostin 1981). During summer months the upper portion of the bluffs on Sargent Beach dry out and crack. The sediment becomes friable and drops off of the bluff in chunks.

The fracturing of the bluff may be quickened by the combined affects of toe undercutting and subaerial exposure. Bluff toe undercutting imparts a tensional force upon the overlying sediments. Throughout the bluff the intergrain attraction forms a strong cohesive bond in wet sediments that is resistant to breakage (Kocurek and Felder 1982). However, when the upper portion of the bluff is sun-dried the intergrain cohesiveness of the sediment grains decrease and the unit becomes brittle. The tension on the dried block of sediment is increased by wave undermining of the lower unit (Figure 30). Eventually, the entire block is released by mass wasting processes. Once the block fails it disintegrates into smaller aggregates that are added to the beach face. Due to their fine-grained nature they are easily swept away with the longshore current (Anderson 1973).

## The Future of Sargent Beach

There is no natural supply of sediment available to nourish the beach. Sargent Beach is part of the fastest eroding coastline of Texas (Morton and

Nummedal 1981). It has been eroding at an average rate in excess of 4 m/yr for nearly two hundred years. The Brazos river system no longer supplies sand to the nearshore system due to the construction of river control structures (Morton and Piper 1975). Further, there is a lack of sand-size material in the nearshore and offshore areas (Weiss and Wilkinson 1988; Wilkinson and Basse 1978; Morton and Winker 1979). A recent field survey conducted by the Army Corps of Engineers confirmed the lack of sand sized sediments in the nearshore region of Sargent Beach (EG&G 1991). The offshore sediments are not suitable as beach material.

# 5 Assessment of Beach Nourishment Alternative at Sargent Beach, Texas

## Introduction

The barrier morphology of the Sargent Beach area between the Gulf and the GIWW is comprised primarily of deltaic muds and marsh overlain by a thin veneer of shelly gravels and fine sand. The island, created by the dredging of the GIWW through the deltaic headland, ranges from 2800 ft wide at the northeastern and southwestern ends to less than 1000 ft wide in the vicinity of the cuts. Dredge disposal mounds adjacent to the GIWW are the highest elevations on the island. In cross-section, the central part of the island between the foreshore and the GIWW has numerous overwash terraces interspersed with low vegetation. There are a few dredge disposal dike areas along the island near survey locations S-14 to S-15 and S-23 to S-24, that have higher elevations (Figure 12). Small (less than 3 ft) incipient dunes are found near the mean high water line and berm crest. The foreshore beach from berm crest to NGVD ranges from 150 to 200 ft wide. Along the northeast (S-18 to S-30) portion of the study beach, the thin sand veneer extends into the water. Along the southwest portion of the study beach, from around S-18 to S-12, exposed surf zone marsh mud forms the low wave cut terrace with a highly irregular vertical face. The wave cut scarp meanders alongshore irregularly with indentations or mini-pocket beaches of sand on a 45 deg angle orientation to the shoreline. From S-13 to S-10 near the unnamed inlet leading to East Matagorda Bay, the beach foreshore is a smooth sandy sloping surface, but the muds are exposed in the low tide terrace area.

One of the options to provide erosion protection to the GIWW, is to construct a beach nourishment project to mitigate the high rates of erosion experienced at Sargent Beach. Beach nourishment can be defined as the artificial placement of suitable sediment to an area of the coast that has a natural deficiency in sediment supply. The concept of beach nourishment in this particular project is different from the typical beach nourishment project. The purpose for most beach nourishment projects is to primarily provide storm protection to upland property. This is accomplished by adding sand into the system by either hydraulic pumping of fill material from a subaqueous borrow area or trucking in sand from an upland or stock pile borrow source. A secondary benefit usually gained by such a project is a wider berm that can be utilized for recreational purposes. In the Sargent Beach case, the main purpose is to maintain at least a 300-ft-wide barrier beach between the Gulf of Mexico and the GIWW, as the beach continues to erode landward through the next 50 years.

## Beach Fill Design Criteria

There are two approaches to beach nourishment design commonly used by the coastal engineer. The first is the fill suitability determination based on the native beach and borrow area sediment grain size, and the second is the numerical modeling of beach profile equilibrium slope and fill template shape. All of these approaches to beach fill design are based on sandy beach areas, where the predominant grain sizes are unconsolidated quartz sand material. Little experience exists on artificial nourishment design on fine cohesive shorelines.

### Fill suitability

Several beach fill models have been established to calculate the "overfill ratio" or fill factor. This is defined as the volume of borrow material that is required to produce a unit volume of stable fill based on the same grain size means and sorting as the native material (Krumbein 1957; Krumbein and James 1965; Dean 1974; James 1974 1975; and Hobson 1977). Each of these fill suitability models require four parameters for calculation: the mean grain-size characteristic of the native beach; the mean of the borrow area; and the sorting value of the native beach and sorting of the borrow. The Shore Protection Manual (U.S. Army 1984) describes the methods of using three models of fill suitability based on the work of the above authors. The Adjusted Shore Protection Manual (Adjusted SPM) Method developed by James (1975) and modified by Hobson (1977) is the preferred method, but the Shore Protection Manual (SPM) Method proposed by Krumbein and James (1965) and the Dean Method (Dean 1974) are also described. Each of these fill factor calculation approaches use many of the same assumptions. Sediments native to the beach are considered to be the most stable for the conditions found on that beach. Local sorting processes will act on the entire volume of fill to achieve a grain size distribution similar to the native sediment at some interval after fill placement. Sorting processes change the fill material into native-like sediments by winnowing out a minimum amount of the original fill. Grain size distributions of both the native and borrow sands are assumed to be normally distributed to simplify calculations (Hobson 1977).

There is some question as to the validity of these assumptions. In five projects studied (Stauble and Hoel 1986) both the native and borrow sediment grain size distributions were not found to be normally distributed. Most offshore borrow area sediments had excess coarse fraction shell material and an excess in finer sizes due to lower energy environments in the borrow area. In some cases the borrow was bimodal and lacked the native beach material (Stauble et al. 1984). These Fill Factor calculation methods have never been fully tested in actual field use and need to be used with caution (U.S. Army 1984). In a review of post-construction resorting on five projects (Stauble and Hoel 1986), it was found that excess fine material in the fill was quickly winnowed offshore and/or downdrift of the fill placement area. In comparing the response of the limited number of fill material grain size distributions at one year after placement with initial borrow versus native distributions, the redistributions played an important role in beach fill stability, but large data scatter provided no clear trends. Each project had enough variability in grain size distributions one year after placement relative to native and borrow, wave climate and other variables to make it difficult to evaluate the role of grain size in fill stability.

A review of the renourishment model established by James (1974), which establishes a technique to predict how often renourishment will be needed, was also examined by Stauble and Hoel (1986), in light of only three projects with sufficient sediment data. James (1975) suggested a delta value of 1.0 (The delta value is a dimensionless parameter related to selective sorting in the environment). Actual calculation of the delta value based on mean grain size values before and after an erosional event were found to give a more accurate picture of renourishment needs (see Stauble and Hoel (1986) for more details). Since only three projects had data that could be used as a check and little previous calibration with actual project data had been done on the renourishment factor, more calibration is needed. The *Shore Protection Manual* (U.S. Army 1984) notes that both the fill factor and renourishment factor models need to be used with engineering judgment and experience.

### Profile design

Modeling of beach nourishment profile response and subsequent design templates have been divided into cross-shore and alongshore changes. This approach has been used to simplify equations and concepts in what in reality is a complex interaction of three dimensional processes. The cross-shore component of this modeling has used the concept of the equilibrium beach where the shape of the beach profile is a response of the beach to coastal processes. In reality the profile, particularly the subaqueous part seaward of the high water line is in a constantly changing dynamic equilibrium. The equilibrium equation $h = A x^{2/3}$ has been used in beach restoration design by Dean (1983). The A parameter is related to grain size, where A decreases with decreasing grain size. To utilize the equation, one grain size is chosen to be representative of the entire profile. This is usually a composite mean grain size. Most applications of the equation have been limited to sand size ocean beach profiles and the A parameter graph only extends to 0.062 mm (4 $\phi$). The finer mean grain size profiles correspond to flatter profiles.

The geometries of design profile cross-sections are presently derived by rule-of-thumb methods based mostly on FEMA estimates of storm surge (Hansen and Byrnes 1991). Mathematical modeling is now being applied to beach fill design and to assessing the design's response to storm-induced erosion. (Kriebel 1986; Scheffner 1989; Larson et al. 1990 and Hansen and Byrnes 1991). Recent development of the beach profile response model SBEACH is based on cross-shore sand transport caused by storm generated waves and water level (Larson and Kraus 1989; Larson, et al. 1990). The model has been applied to beach fill template designs and their response to model storms. The present model uses only one mean grain size in the sand range at a time. Analysis of data from the FRF (Stauble 1991) indicated that there can be a wide range in grain size distribution means in the cross-shore direction on a sandy beach with an equally diverse range in grain size distributions. In spite of these limitations, some agreement in model response has been found when compared to prototype cross-shore fill project response (Hansen and Byrnes 1991).

When using the models to predict alongshore response along sandy beaches where longshore transport is significant another set of models is required. One- and two- line models have been used to predict alongshore fill response (Manual on Artificial Beach Nourishment 1986). These models are simplifications of the complex interaction of processes that occur in nature.

Both the cross-shore and alongshore models are based on sand transport equations. There are limits to applying models in cohesive environments, in that the cohesive material is harder to entrain and once in the water column, will be transported long distances as suspended mater. The thin sand veneer in the active beach system at the present time is a thin layer over a mud base. As the beach continues to erode landward, the profile will lose most of its thin sand veneer as overwash and to longshore transport. The nearshore area is composed of mud material, with whole and fragmented shells (Nienaber 1963; Weiss and Winkler 1988; Morton and Pieper 1975).

## Historic Trends in Profiles

A review of the wading depth profiles from 1970 to 1990 at survey station S-4 just northeast of the highway FM 457 has shown the landward retreat of the shoreline (Figure 31). These were short profiles but all seemed to reach a similar depth in the most seaward portion of the profile. To examine the slope of the nearshore area, a series of long profiles were collected for this project ranging from 5,000 to 8,000 ft offshore. These long profiles show a gentle flat sloping profile. A bathymetric chart, done in 1937 by the then Coast and Geodetic Survey was digitized to compare the long-term change in the offshore slope. A comparison of the two long profiles along the S-17 transect (approximately 2000 ft northeast of S-4) are shown in Figure 32. This 53 year time spread illustrates the landward retreat of the entire profile. The 1937 profile extended offshore some 11,500 ft from the present survey baseline. The slope

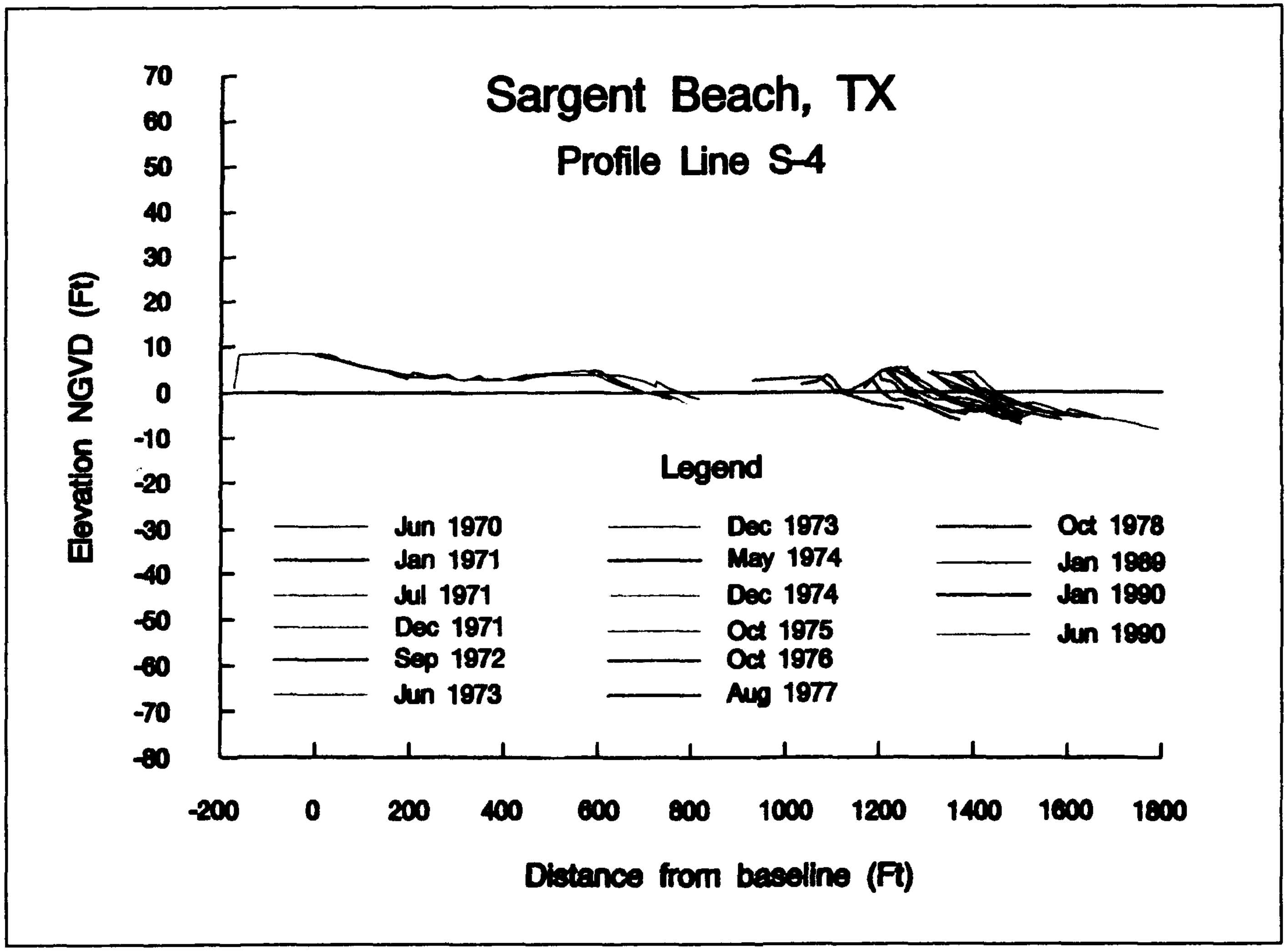



Figure 31. Landward retreat of wading depth profiles surveyed at S-4 from 1970 to 1990 (profile data supplied by Galveston District)

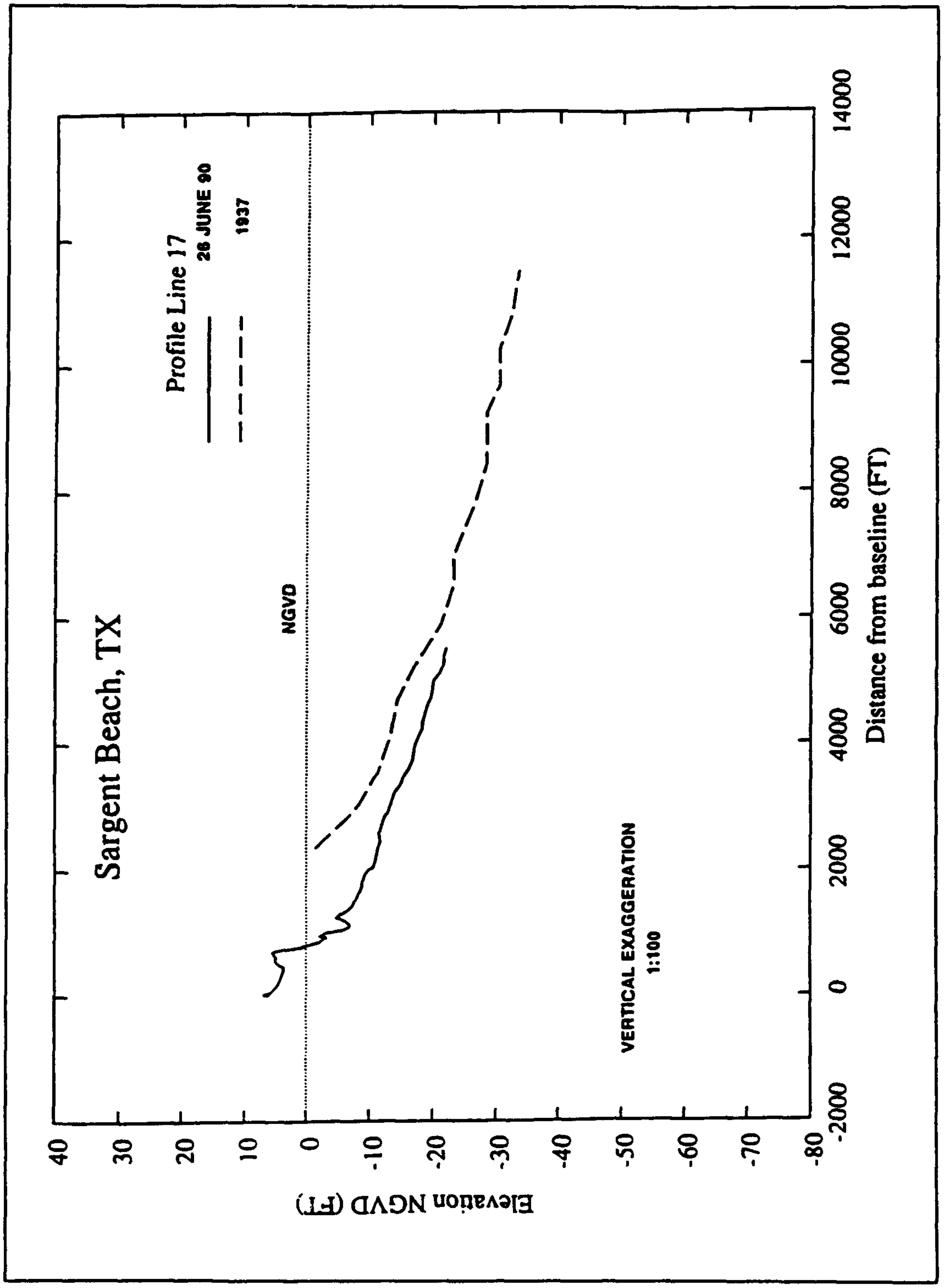



Figure 32. Landward retreat of the nearshore profile illustrated by the 1937 and 1990 profiles surveyed at S-17

of the two profiles is very close, indicating that the processes and bathymetric response have remained similar over this 53 year time period. Superimposing the two profiles on top of each other (Figure 33) shows that except for the nearshore bar measured in 1990 (but probably skipped over in 1937), the profiles are strikingly similar in shape. In order to assess the possible future profile at Sargent Beach, two plots were constructed. Figure 34 shows both the 1937 and 1990 profiles translated landward approximately 32 years from now or when the shoreline at the present rate of retreat taken as an conservative average of 30 ft/yr based on data from Table 7, reaches the present GIWW shoreline. At that point in time (or sooner using one of the higher erosion rates) the barrier island will have eroded away and the Gulf shoreline will be along the GIWW. The higher rate of erosion between McCabe's and Charpiot's Cuts (see Chapter 3) is speculated to be because of the outcropping of the mud cliffs, which present a near vertical face and erode at a higher rate due to several possible mechanisms.

Figure 35 shows both the 1937 and 1990 profile positions at approximately 50 years into the future, based on the life of the project at profile location S-17. Without any shore protection the shoreline would be 1,500 ft landward of the present position, using the average erosion rate of 30 ft/yr. Appendix C shows a similar type of analysis for profile locations S-13 southwest of McCabe's Cut, S-20 northeast of Charpiot's Cut, S-24 between Charpiot's Cut and Cedar Lakes, and S-28 near Cedar Lake (see Figure 12 for profile locations).

A plot of the nearshore bathymetry from the 1937 NOAA smooth sheets H-6314 (Bryan Beach to Choctaw Lake) and H-6315 (Choctaw Lake to Brown Cedar Lake) in Figure 36a shows that the nearshore area had nearly straight parallel contours gently sloping in the offshore direction. The 1990 nearshore bathymetry collected for this study by CERC also shows straight parallel contours (Figure 36b). A difference map was produced using the Contour Plotting Software package (CPS) which compared the 1937 and 1990 bathymetry. Figure 37 shows the accretion in green in the offshore area where sediment has been deposited over the 53 year period. In the northeast section in the vicinity of Cedar Lakes there is almost all accretion, possibly due to the erosion of the Brazos River Delta in recent years (Field et al. 1990). The nearshore area in the rest of the study area shows erosion in red, indicating that the shelf area Figure 32. Landward retreat of the nearshore profile illustrated by the 1937 and 1990 profiles surveyed at S-17 closest to the beach has eroded during this period. A small area of accretion can also be seen in the vicinity of McCabe's Cut where the inlet's ebb tidal delta probably was located. The general trend is one of erosion adjacent to the beach, with accretion some 3,000 to 4,000 ft offshore from the present shoreline.

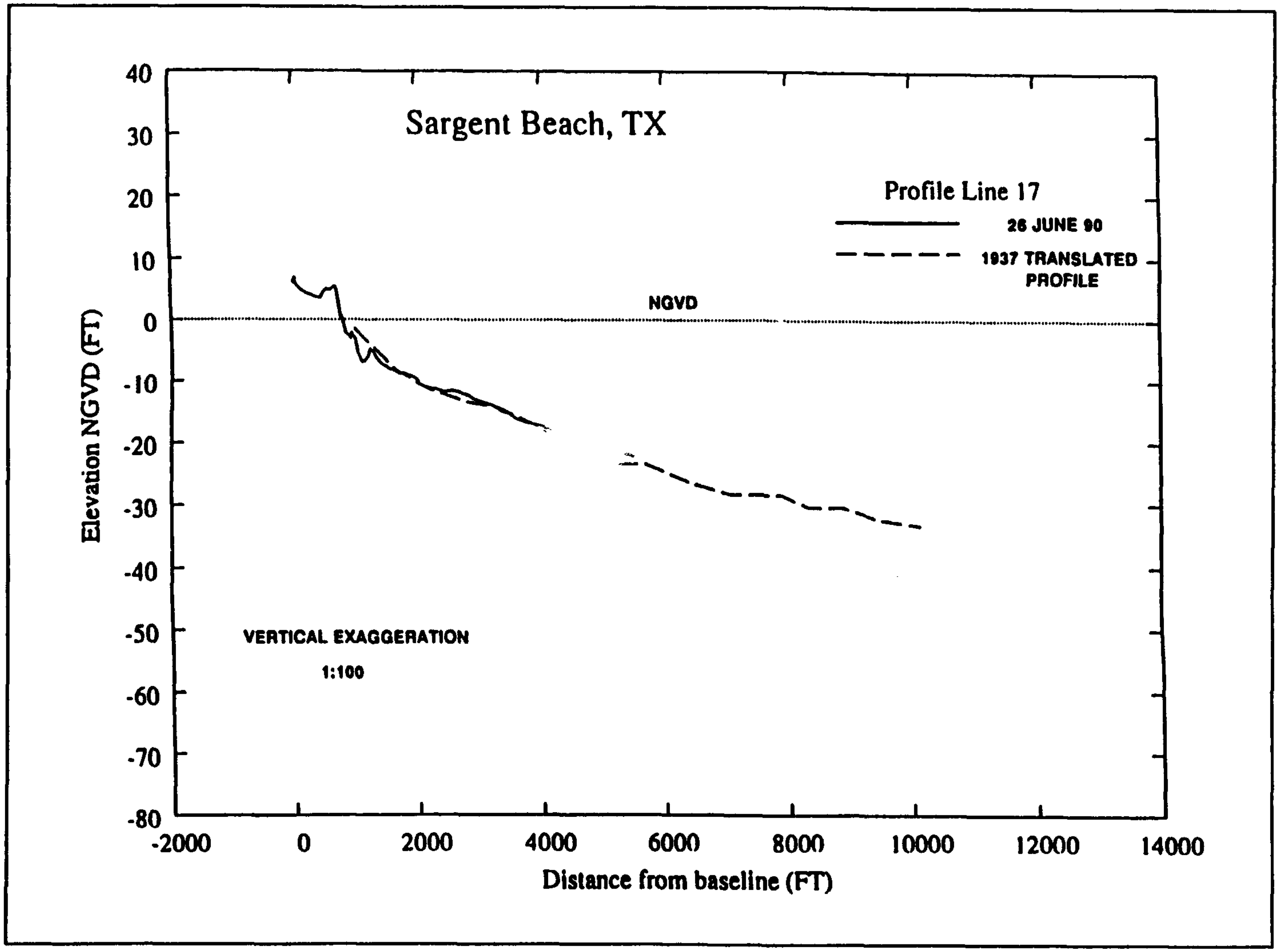



Figure 33. Superposition of 1937 nearshore profile over 1990 profile shows similar slope and overall profile shape over the 53-year span at profile S-17

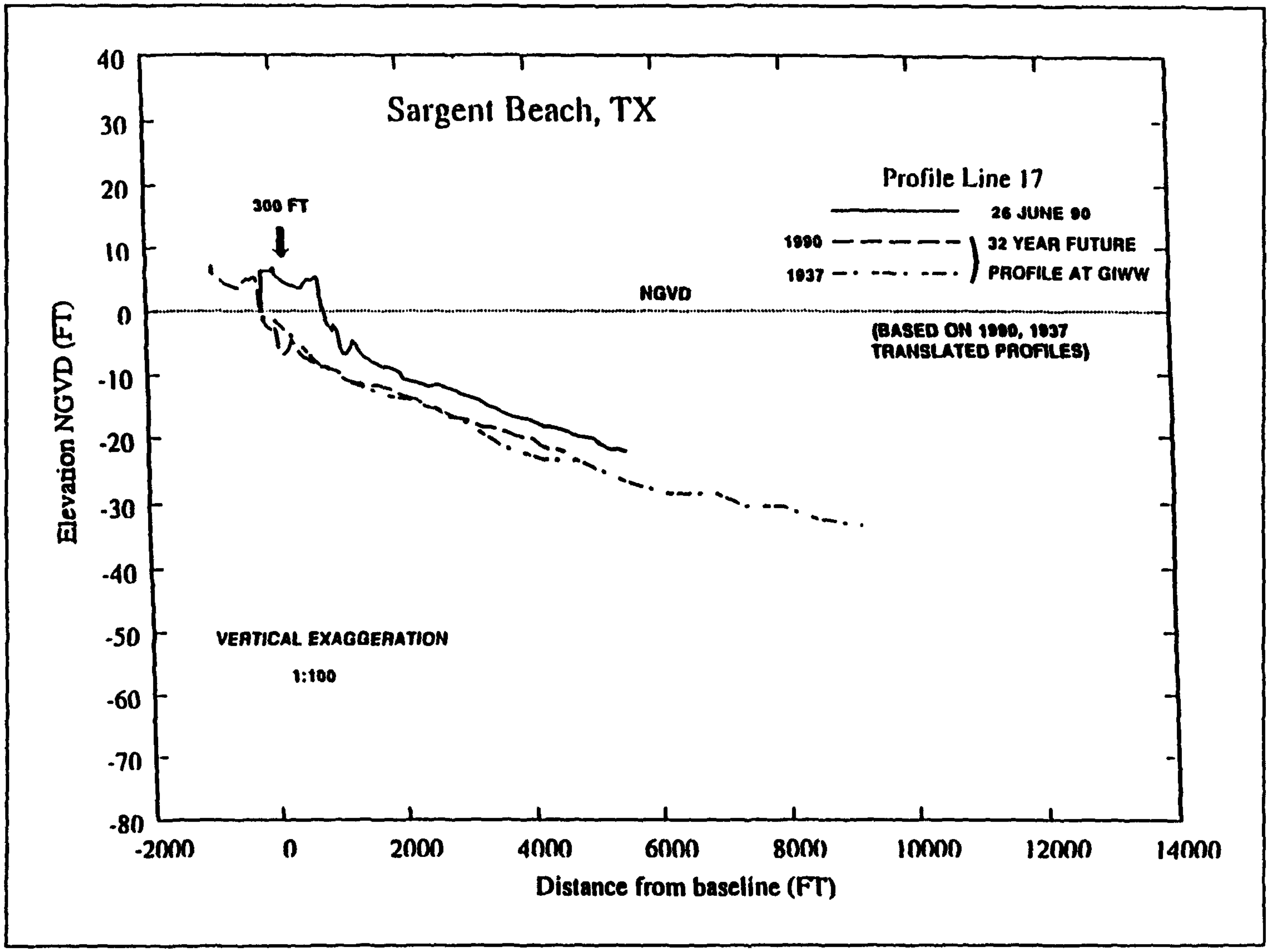



Figure 34. Translation of the 1937 and 1990 S-17 profiles landward to intersection with the GIWW. Calculated *period of 32 years, based on an erosion rate of 30 ft/yr.* Depth at translated profile at 300 ft present island width will be around -4 ft

| Table 7<br>Sargent Beach Erosion Rates | | |
|---|---|---|
| Time Period | Method of Calculation | Rate of Erosion |
| 1942-1989 | Aerial Photography (Part III) | 25 ft/yr (ave. for study)<br>30 ft/yr (between cuts)<br>22 ft/yr (NE of Charpiot's Cut) |
| 1965-1989 | Aerial Photography (Part III) | 30 ft/yr (ave. for study)<br>36 ft/yr (between cuts)<br>25 ft/yr (NE of Charpiot's Cut) |
| 1970-1990 | S-4 Profiles (Part III) | 37 ft/yr (just NE of McCabe's Cut) |
| 1937-1990 | S-17 Profiles | 28 ft/yr (between cuts) |
| 1978-1989 | Morton (1990) | 33 ft/yr (between cuts) |

# Future Depth of Erosion

With the basic requirement to maintain a 300-ft-wide barrier between the Gulf and the GIWW, a calculation of the depth of erosion of the native profile can be done. Assuming a basic profile shape conservation as the shoreline continued to erode, the proposed 300-ft-wide landform gulfward of the GIWW, would intersect the profile at a depth of around -4 ft as the profile form retreats to the GIWW. Over the fifty year life of the project, the profile form would have eroded to a -8 foot depth at the base of the 300-ft-wide island width.

# Beach Nourishment Requirements

To provide the required storm protection and prevent the erosion of the barrier island, a beach fill design template with a dune is suggested based on Hansen and Byrnes (1991) as the design template to provide the maximum protection. The design template contains a 50 foot wide "dune" in the back-shore area (Figure 38). This "dune" is really a mound of sand stockpiled to provide additional sand to counter expected erosion of the berm fill sand. The location of the dune was chosen at 600 ft gulfward of the GIWW to provide ample protection to the island. This is farther gulfward than the required 300-ft-wide island, but the greater width of island would provide more storm protection. The elevation of the dune was chosen at +8 ft NGVD, as this is the elevation of the dredge mounds on the back side of the island next to the GIWW. The +8 foot elevation may provide overtopping protection for up to a 15 year return period storm (Part II). Storm surge water levels above this will overtop the dune and penetrate landward, transporting the fill sand landward. The experience with Hurricane Hugo's impact on the South Carolina coast indicated that dunes greater than 15 ft high survived this 100 year return period storm and did provide protection to upland property, while lower dunes were eroded as overwash landward onto the back beach area (Stauble, et al. 1991). This storm can be considered an extreme event, and providing

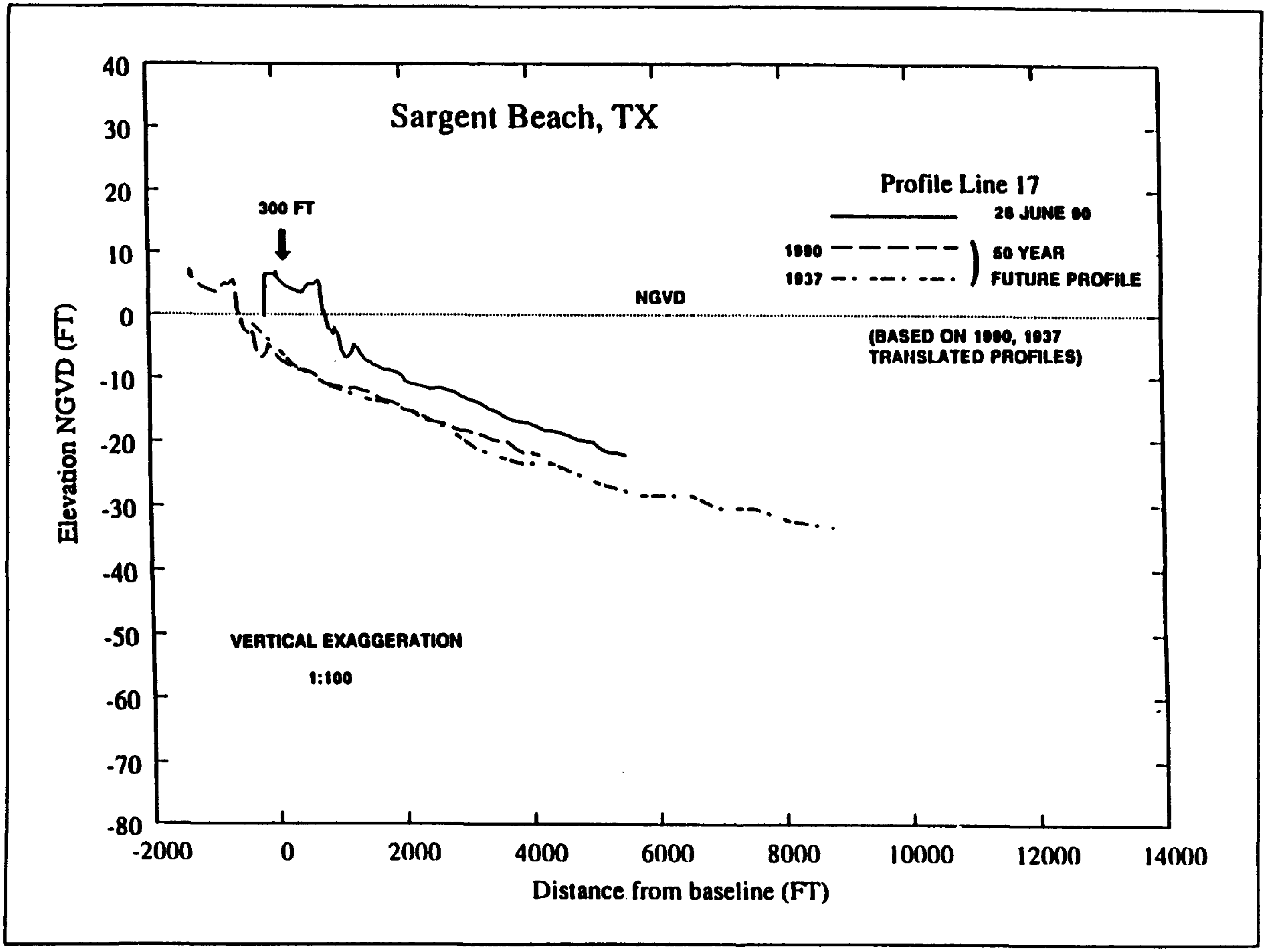
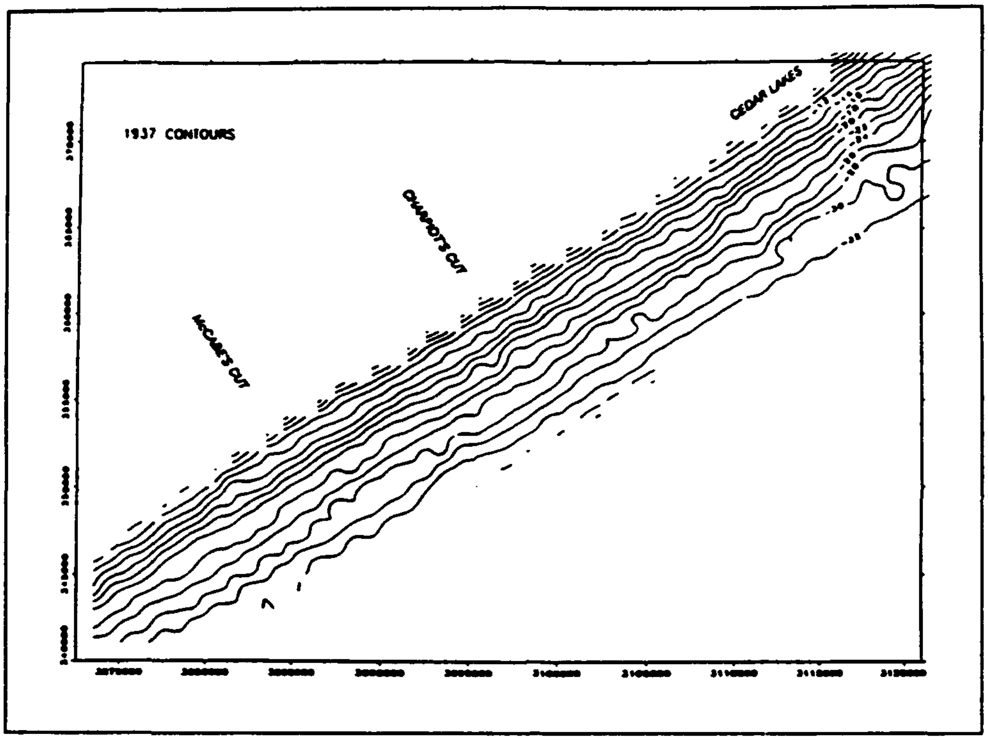
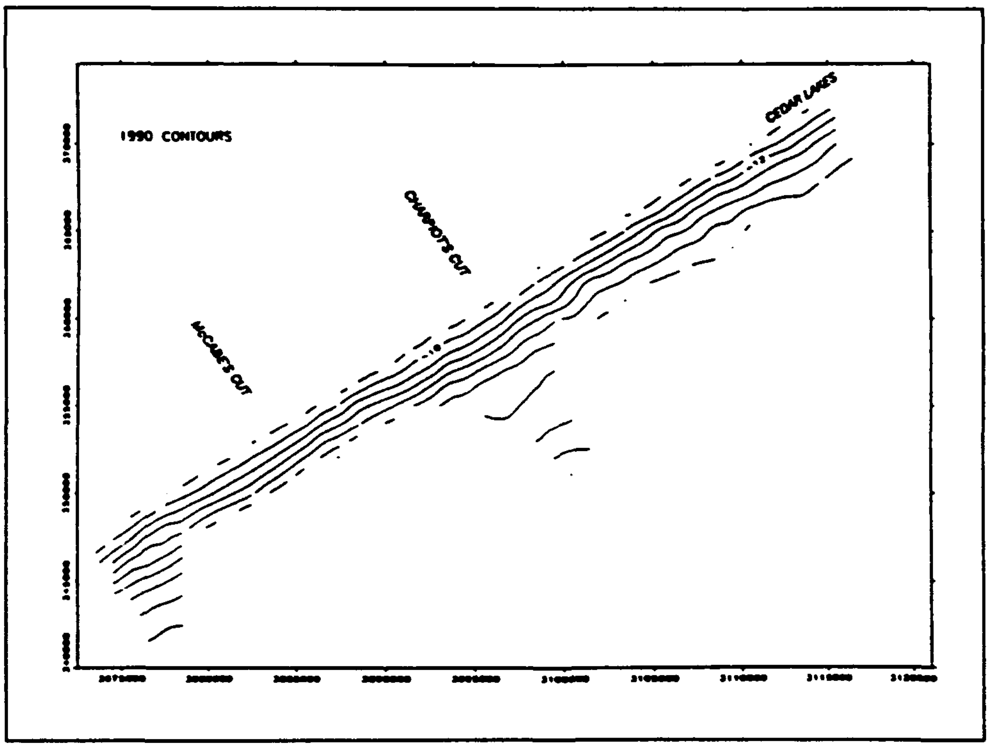



Figure 35. Translation of the 1937 and 1990 S-17 profiles landward to estimated position in 50 years, based on 30 ft/yr erosion rate. Depth at translated profile at 300 ft present island width will be around -8 ft




a. From 1937 NOAA smooth sheet




b. From 1990 CERC survey

Figure 36. Nearshore bathymetry

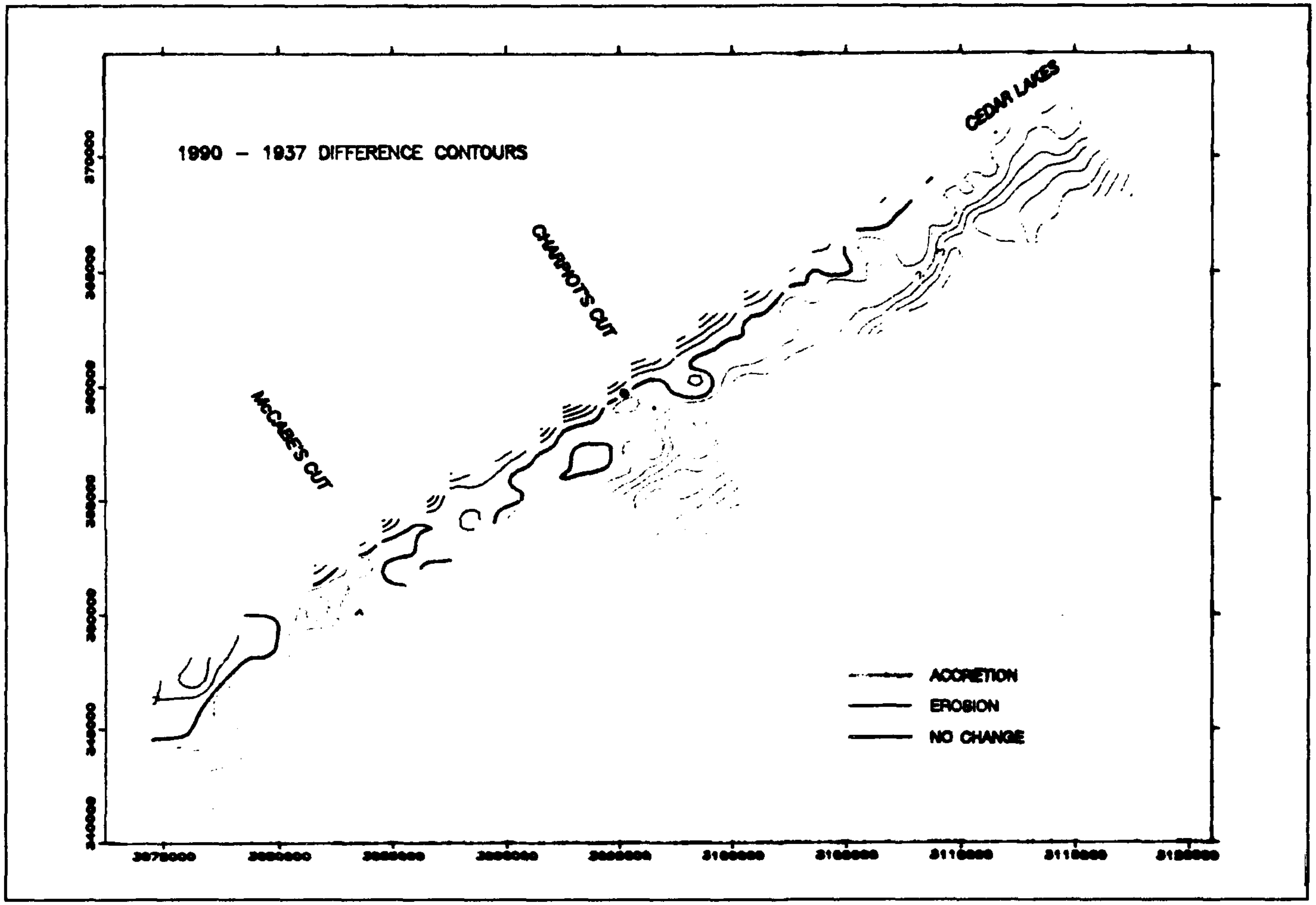



Figure 37. Difference map of 1937 and 1990 bathymetry off Sargent Beach showing accretion in the nearshore in the northeast portion of the study area. This accretion may be from erosion of the Brazos River Delta just around 10 miles (16 km) up drift. Erosion of the nearshore is seen for the remainder of the study area

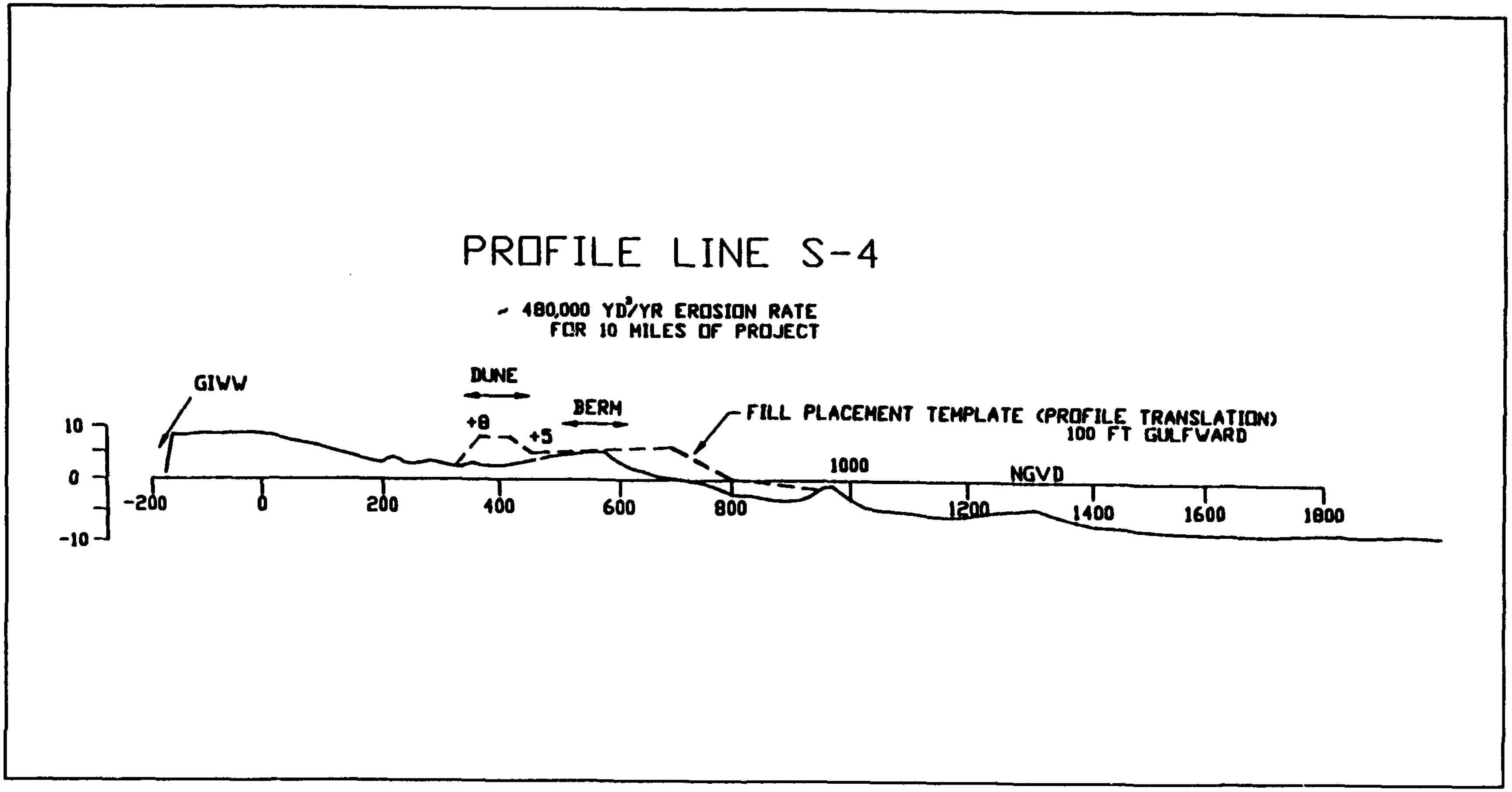



Figure 38. Design template based on typical profile (in vicinity of S-4 and S-17) for beach nourishment at Sargent Beach

protection for a storm of this magnitude is beyond the scope of design. However storm protection of 15 year return period storms can be considered reasonable.

The fill profile extends gulfward from the base of the dune to 100 ft seaward of the present berm crest. The existing equilibrium profile has been translated seaward as suggested by Hansen and Lillycrop (1988) to provide a realistic minimum volume of fill. Past design profiles have predicted underfilling, based on monitoring of fill behavior. Fill has been placed to the approximate depth of closure in vicinity of the first offshore bar to ensure enough volume to provide the needed protection. A 100 foot wide berm was chosen, given the high rate of natural erosion along this beach. This should provide three years of berm material using the 30 ft/yr average erosion rate. The dune will provide additional storm surge protection, as well as act as a storage area for additional sand. The actual protection provided will depend on storm frequency (Stauble and Holem 1991). Recent monitoring studies of sandy beach fill performance at Ocean City, MD (Stauble 1990) and Myrtle Beach, S.C. (Stauble et al. 199[illegible]) have shown that storms remove fill from the subaerial placement area, but transport the sand to the offshore area. Most of the fill material can be accounted for and is not lost from the system. Return movement of this displaced fill material onto the foreshore area is in the process of being documented. Over the long term, there is a gradual movement of the fill material offshore and alongshore, requiring renourishment of the project. Calculation of the renourishment intervals is inexact at the present time.

Using the BEach profile Re-Molder (BERM) program (Hansen 1991), a volume of fill material was calculated for the typical profile shown in Figure 38. The volume of fill sand for this design profile is 58 $yd^3$/ft. Multiplying this volume by the length of the fill area of 10 miles the total volume of fill needed is estimated at 3,000,000 $yd^3$. Certain low areas such as at McCabe's Cut and some areas on the northeastern beach area may need additional fill to raise the elevations on old lake beds and overwash fans. This volume could be offset by less material required in the elevated areas of old dikes used in the disposal of dredge material south of McCabe's Cut (S-14 area) and along the northeast beach (S-22 to S-24 area) from the maintenance of the GIWW. These dikes are made from fine mud material and will be eroded faster than fill composed of sand size material.

It was calculated that around 480,000 $yd^3$/yr would erode from the 10 mile stretch of beach under natural conditions. Assuming a constant rate of erosion each year, the 3,000,000 $yd^3$ of initial fill would last for six years. Renourishment would be required in about four to five years to supply enough sand to provide adequate shore protection. The exact volume of renourishment would have to be determined by monitoring the project and measuring the amount of fill remaining during each successive year.

# 6 Summary

Water levels and wave heights near the shore of Sargent Beach, TX, for various return periods, have been estimated using available historical information. Water levels and wave heights are associated with hurricane categories and hurricane categories are associated with return periods. Return periods were estimated using the historical frequency of occurrence of hurricanes. Water level estimates were based solely on observations since model studies were limited for this site; only individual storm events were available. Gage-recorded water levels of five storms, from 1949 to 1983, passing within a 75-n.m. radius of Sargent Beach were chosen to provide representative water levels. Return periods of storms in the 75-n.m. radius were determined by the HURISK program. The estimated water-level envelope and associated return periods range from total water levels of 4-6 ft above mean sea level having a return period of about 7 years to a total water level of approximately 14-16 ft with a return period of about 53 years.

Information of wave heights near Sargent Beach, TX during hurricanes was obtained mostly from WIS Report 19 (Abel et al. 1989), its database and addendum. Twenty-five hurricanes were simulated during the hindcast period of 1956-1975. Twenty-four of these hurricanes caused high wave energy at hindcast station 9 which is in a depth of about 85 ft and is the closest station to the project site. Return period wave heights and related peak periods at this station were estimated from these results. The estimated wave heights range from about 3 meters with a peak period of nearly 6 sec having a return period of approximately 5 years to a wave height of about 12 m with a peak period of roughly 12 sec having a return period of approximately 50 years. It is important to remember that the wave conditions only apply to this particular location. This level of analysis is acceptable for a feasibility study, but is not recommended for design.

An analysis of six sets of aerial photography over a 46-year period was performed to assess the change in the high water and duneline along a narrow portion of a deltaic headland coast in the vicinity of Sargent Beach, TX. The close proximity of the GIWW to this rapidly eroding shoreline and the fear of breaching by the Gulf has lead to this assessment of the rate and pattern of shoreline change and its mechanism. The measurements indicate that the shoreline is retreating landward, but not at a uniform distance along the study area from Cedar Lake to East Matagorda Bay. Greater landward movement has occurred in the area adjacent to and between two man-made cuts in the "barrier island" known as McCabe's and Charpiot's Cuts. Less rapid but still severe landward movement was measured at the northeastern and southern limits of the study area. Erosion rates have averaged 30.3 ft/yr between the two cuts and 22.8 ft/yr over the rest of the shoreline. The rate of erosion has not been constant over the 46 years of the study, ranging from a low of 15.3 ft/yr between 1958 and 1965 to a maximum of 40.3 ft/yr between 1965 and 1971. Change in erosion rates may be a function of frequency of severe storms, with two hurricanes impacting the study area in 1970 and 1971. The years between 1958 and 1965 were relatively low storm occurrence years.

Examination of the site and analysis of surface sand samples and shallow hand auger cores from four shore-normal transects show a unique vertical sediment distribution for an open coast beach. There exists only a thin veneer of fine sand containing a high percentage of shell hash material on the surface of the barrier and beachface over lying a uniform fine fluvial-deltaic silt/clay deposit. The composite sediment grain sizes from the surface sand deposits indicate a uniform size along the study area. The only variability is in the shell content, which was higher at Transects S-2 and S-4. The median grain sizes ranged from 0.14 mm (2.82 $\phi$) at A1 to 0.24 mm (2.09 $\phi$) at S-2. The mean reflects the shell content and ranged from the fine 0.06 mm (4.03 $\phi$) at A-1 to the coarser 0.46 mm (1.13 $\phi$) at S-2.

Below the unconsolidated sand layer is a thick layer of cohesive deltaic headland mud, composed of clayey-silt size material. This mud outcrops on the foreshore area between the two Cuts creating an irregular alongshore low tide terrace, with steep vertical scarps in the vicinity of the low tide line. The outcropping mud shore features correspond well with the areas of high erosion. The less rapidly eroding northeast section of the study area and the extreme southwestern section have a typical low sloping sandy beach out into the low tide surf zone. The sand thickness is greatest at the berm crest along the study transects ranging from 2.92 ft (0.89 m) in the northeast at S-2 to 1.97 ft (0.6 m) between the Cuts at S-4. This area has a low to non-existent primary duneline and the area is subject to overwash during extreme wave conditions. Sand thicknesses on the overwash range from 1.83 ft (0.56 m) at S-2 to between 1.38 to 1.87 ft (0.42 to 0.57 m) at S-4 suggesting that the overwash deposit thickness may be consistent along the study area. Sand thickness to the mud layer was very thin but covered the foreshore of Cedar Lakes and S-2, while the mud outcropped at S-4 and was exposed at the low-tide terrace surface at A-1. The latest period from 1986 to 1989 indicated that the shoreline change rate had slowed for the area northeast of Charpiot's Cut which included the Cedar Lake and S-2 sediment transects. This may indicate a volume of sand that is in the longshore transport system in this area. Sand is starved from the beach system in the southwestern section, indicated by a constant erosion rate since the 1971-1986 interval, allowing the mud to be exposed.

Sargent Beach is eroding at a faster rate than any Texas beach. The rate of erosion is due to a lack of sand size material in the system. There is not enough input of new sand into the system to replace the sediments that have been removed and the beach continues to erode. The fact that the beach face is comprised of fine-grained bluffs may retard the rate of erosion somewhat. If the seaward end of the precipice were used as the gauge to measure shoreline retreat, it may appear that the beach is eroding slower than a sandy beach of comparable size. This point of measurement may, however, be deceptive. The formation of low swales adjacent to the bluffs channelize wave bores causing lateral erosion of the fine grained material. The swales also provide a path for washover channels to form. Washovers will lower the beach elevation.

The beach profile cannot recover following a storm event. Once the bluffs fail, there is no mechanism to add sediment back to them. The narrow beach is comprised of a relatively impermeable shelly gravel. The uprush of the wave bore is not absorbed by vertical percolation. The full force of the breaking wave is felt by the front wall of the bluff. In addition, the impermeable lower unit of shelly gravel acts as a ramp. In the swales the wave bore will be constricted. As a result, the bore velocity will be increased and the effects of the washover will be observed a considerable distance landward. Because of its low profile, Sargent Beach will be especially vulnerable to hurricane events. The combination of elevated tide levels and intensified storm waves will accelerate beach erosion and likely breach an opening between the beach and the Gulf Intracoastal Water Way.

The offshore profiles indicate that the shoreface is eroding at a rate commensurate with shoreline retreat. The upper portion of the profile is steeper than normal due to the cohesive nature of sediments on the beach face. Regardless, the depth limit of the shoreface retreat will still be defined by the wave base.

The long term erosion rates using historical aerial photography and beach profiles dating back to 1937 indicate an average erosion rate around 25 ft/yr. Since construction of flood control structures on the Brazos River and others in the area, the main source of sand to the beaches has been reduced. From 1965-1971, Sargent Beach experienced its largest increase in erosion rate (Chapter 3), in part due to an increase in frequency and intensity of storms (Chapter 2). The average erosion rate has increased to 30 ft/yr. The beach area with low mud cliffs between McCabe's and Charpiot's Cuts has experienced higher rates (up to 37 ft/yr) than the flatter sloping sand beach to the northeast of Charpiot's Cut (25 ft/yr).

Most documented past nourishment projects have been used on beaches with low to moderately high erosion rates. All of these areas have been on sandy ocean beaches. The uniqueness of the Sargent Beach deltaic mud headland sediment, with its thin sand veneer and mud cliff erosion mechanisms, present some unique challenges to the design of a beach nourishment project. Present knowledge of sediment suitability and fill profile template design are inexact and are based on sand size native and borrow area sediments. Little knowledge exists on their applicability in limited sand beaches within a fine grained mud environment. Since this beach area has a high historical erosion rate and present beach nourishment design is based on sandy beach environments, the option of beach nourishment as an alternative for protection of the GIWW is an alternative for which there is minimal design guidance or historic precedence. The most advantageous design criterion for this area would be to make sure that a sufficient volume of fill material is placed in this sediment starved area. In addition the source for the required volumes of suitable borrow material may also be an important limiting factor.

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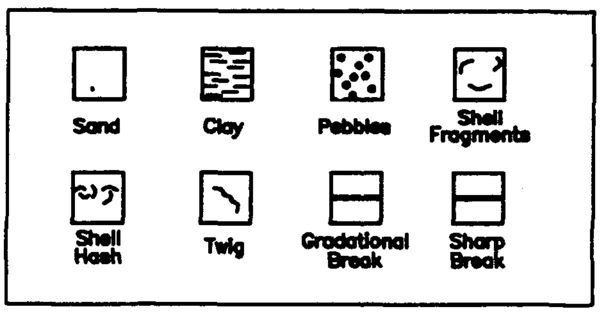
# Appendix A
# Core Logs

Appendix A contains 11 visually described core logs. The cores were collected along shore normal transects near known survey markers of Sargent Beach, Texas. Six of the cores are hand auger cores of about 6-ft in length while the remaining five are 3-in-diam aluminum pipe cores. Each core log has an illustrated and a verbal description of the material in the core. An explanation of core labels are as follows:

| | |
|---|---|
| HA | Hand auger core |
| Al core | Aluminum core 3-in-diam |
| S4-1 | Station 4, core number 1 |
| C3 | Cedar Lakes location, core number 3 |

Other data includes total length of core, descriptive location of core (eg. mid-tide), and occasional various inclusions.




Legend of core logs

Hole No.

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 1 OF 2 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT Sargent Beach, TX | 10. SIZE AND TYPE OF BIT |
| 2. LOCATION (Coordinates or Station) Overwash | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 3. DRILLING AGENCY | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) HA-S4-1 | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED: 1 — UNDISTURBED: |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT. | 15. ELEVATION GROUND WATER |
| | 16. DATE HOLE — STARTED: 11-20-90 — COMPLETED: ------- |
| 7. THICKNESS OF OVERBURDEN | 17. ELEVATION TOP OF HOLE |
| 8. DEPTH DRILLED INTO ROCK | 18. TOTAL CORE RECOVERY FOR BORING % |
| 9. TOTAL DEPTH OF HOLE 194 cm | 19. SIGNATURE OF INSPECTOR CRL |

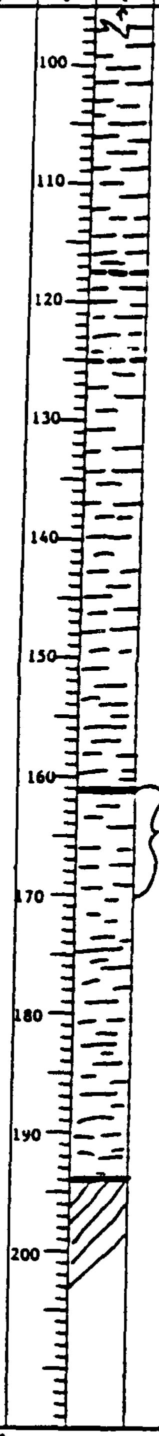
| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| | 10 | | Light brown sand with abundance of shell fragments and few whole shells. | | | |
| | 20 | | | | | |
| | 30 | | Iron stained light brown sand with shell fragments. | | | |
| | 40 | | Light brown sand with some iron staining and some mottling with dark gray clay. | | | |
| | 50 | | Medium brown sand mottled with dark gray clay. | | | |
| | 60 | | Reddish medium brown clay mottled with dark gray to black clay. | | | |
| | 70 | | Abundance of dark gray to black clay. | | | |
| | 80 | | Medium to dark brownish gray clay mottled with dark gray to black clay. | | | |
| | 90 | | | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. | PROJECT | HOLE NO.

**DRILLING LOG (Cont Sheet)** | ELEVATION TOP OF HOLE | **Hole No.** HA-S4-1

PROJECT: Sargent Beach, TX | INSTALLATION: Overwash | SHEET 2 OF 2 SHEETS

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| | | | Medium to dark brownish gray clay with some red and yellow iron staining. | | | |
| | | | Medium to dark gray clay with some red iron staining. | | | |
| | | | Medium to dark brownish gray clay with abundance of yellow iron staining | | | |
| | | | High abundance of red iron staining. | | | |
| | | | Medium to dark grayish brown clay with abundance of red iron staining. | | | |




ENG FORM 1836-A (ER 1110-1-1801) | PROJECT | HOLE NO.

Hole No.

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 1 of 2 SHEETS |
|---|---|---|---|

1. PROJECT: Sargent Beach, TX
2. LOCATION: Berm Crest
3. DRILLING AGENCY:
4. HOLE NO.: HA-S4-2
5. NAME OF DRILLER:
6. DIRECTION OF HOLE: VERTICAL / INCLINED ___ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN:
8. DEPTH DRILLED INTO ROCK:
9. TOTAL DEPTH OF HOLE: 195 cm
10. SIZE AND TYPE OF BIT:
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL:
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
14. TOTAL NUMBER CORE BOXES:
15. ELEVATION GROUND WATER:
16. DATE HOLE: STARTED 11-20-90 / COMPLETED ———
17. ELEVATION TOP OF HOLE:
18. TOTAL CORE RECOVERY FOR BORING: %
19. SIGNATURE OF INSPECTOR: GRL

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| | 0–23 | | Light brown (tan) sand with some shell fragments. Few whole shells. | | | |
| | 23–33 | | Light to medium brown shelly sand with few whole shells. | | | |
| | 33–44 | | Light to medium brown sand with abundance of shells. Few whole shells. | | | |
| | 44–56 | | Light brown (tan) sand with some shell fragments. Red iron staining at 53 cm. | | | |
| | 56–61 | | Light brown sand with some shell fragments mottled with medium gray clay. | | | |
| | 61–80 | | Roots / Roots — Light brown sand mottled with medium gray clay, mostly clay. | | | |
| | 80–86 | | Dark gray clay mottled with medium reddish brown clay, mostly dark gray. | | | |
| | 86–96 | | Medium reddish brown clay mottled with dark gray clay, mostly reddish brown clay. | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. | PROJECT | HOLE NO.

**DRILLING LOG (Cont Sheet)** ELEVATION TOP OF HOLE — **Hole No.** HA-S4-2

PROJECT: Sargent Beach, TX — INSTALLATION: Berm Crest — SHEET 2 OF 2 SHEETS

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| | 100 | | Medium to dark gray clay mottled with reddish brown clay. | | | |
| | | Roots | | | | |
| | 110 | | Medium to dark gray clay. | | | |
| | | Shell | | | | |
| | 120 | | Dark gray clay mottled with yellowish medium gray clay. | | | |
| | 130 | Roots | | | | |
| | 140 | | Medium gray clay mottled with yellowish medium gray clay. | | | |
| | 150 | | | | | |
| | 160 | | Medium gray clay mottled with reddish gray clay. | | | |
| | 170 | | Medium gray clay mottled with yellowish and reddish gray clay. Mostly medium gray clay. | | | |
| | 180 | | Medium to dark brown clay mottled with reddish gray clay. | | | |
| | 190 | | | | | |
| | 200 | | | | | |

ENG FORM 1836-A — PROJECT — HOLE NO.

Hole No.

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 1 of 1 SHEETS |
|---|---|---|---|
| 1. PROJECT Sargent Beach, TX | | 10. SIZE AND TYPE OF BIT | |
| 2. LOCATION (Coordinates or Station) Mid/Low Tide | | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) | |
| 3. DRILLING AGENCY | | 12. MANUFACTURER'S DESIGNATION OF DRILL | |
| 4. HOLE NO. (As shown on drawing title and file number) HA-S4-3 | | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED | |
| 5. NAME OF DRILLER | | 14. TOTAL NUMBER CORE BOXES | |
| 6. DIRECTION OF HOLE: VERTICAL / INCLINED ___ DEG. FROM VERT. | | 15. ELEVATION GROUND WATER | |
| 7. THICKNESS OF OVERBURDEN | | 16. DATE HOLE: STARTED 11-20-90 / COMPLETED ——— | |
| 8. DEPTH DRILLED INTO ROCK | | 17. ELEVATION TOP OF HOLE | |
| 9. TOTAL DEPTH OF HOLE 98 cm | | 18. TOTAL CORE RECOVERY FOR BORING % | |
| | | 19. SIGNATURE OF INSPECTOR SLL | |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| | | | Fine sand mixed with brown clay. Mostly clay. | | | |
| | 10 | | | | | |
| | | | Brown clay mottled with black clay. | | | |
| | 20 | | | | | |
| | 30 | | | | | |
| | | | Dark brown clay mottled with black and brown streaks. | | | |
| | 40 | | | | | |
| | 50 | | | | | |
| | 60 | | Brown clay. | | | |
| | 70 | | | | | |
| | 80 | | Dark gray clay. | | | |
| | 90 | | Brown mottled clay. | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. | PROJECT | HOLE NO.

Hole No.

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 1 OF 1 SHEETS |
|---|---|---|---|
| 1. PROJECT: Sargent Beach, TX | | 10. SIZE AND TYPE OF BIT | |
| 2. LOCATION (Coordinates or Station): Station 2 Mid-tide | | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) | |
| 3. DRILLING AGENCY | | 12. MANUFACTURER'S DESIGNATION OF DRILL | |
| 4. HOLE NO. (As shown on drawing title and file number): S2 - A1 Core | | 13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED | |
| 5. NAME OF DRILLER | | 14. TOTAL NUMBER CORE BOXES | |
| 6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | | 15. ELEVATION GROUND WATER | |
| 7. THICKNESS OF OVERBURDEN | | 16. DATE HOLE: STARTED 11-19-90 / COMPLETED | |
| 8. DEPTH DRILLED INTO ROCK | | 17. ELEVATION TOP OF HOLE | |
| 9. TOTAL DEPTH OF HOLE: 53.5 cm | | 18. TOTAL CORE RECOVERY FOR BORING % | |
| | | 19. SIGNATURE OF INSPECTOR: GLL | |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| | 0–21 | | Light brown shelley sand. | | | |
| | 21–24 | | Flat, round pebble. | | | |
| | 24–42 | | Light brown sand with abundance of shell fragments. | | | |
| | 42–44 | | Large shell fragment. | | | |
| | 44–50 | | Light brown sand with some shell fragments. | | | |
| | 50–53.5 | | Gray sand with shell fragments. | | | |

Depth scale: 10, 20, 30, 40, 50, 60

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. | PROJECT | HOLE NO.

Hole No.

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 1 OF 1 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT Sargent Beach, TX | 10. SIZE AND TYPE OF BIT |
| 2. LOCATION (Coordinates or Station) Mid-tide / Low-tide 0.62 meter | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 3. DRILLING AGENCY Station 2 | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) S2 - A1 Core | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT. | 15. ELEVATION GROUND WATER |
| | 16. DATE HOLE — STARTED 11-20-90 — COMPLETED —— |
| 7. THICKNESS OF OVERBURDEN | 17. ELEVATION TOP OF HOLE |
| 8. DEPTH DRILLED INTO ROCK | 18. TOTAL CORE RECOVERY FOR BORING % |
| 9. TOTAL DEPTH OF HOLE 60 cm | 19. SIGNATURE OF INSPECTOR GKL |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| | | | Light brown sand with some shell fragments and whole shells. | | | |
| | | | Light brown shelly sand. | | | |
| | 10 | | | | | |
| | | | Medium brown to dark gray sand. | | | |
| | | | Medium brown clay. | | | |
| | 20 | | | | | |
| | | | Medium brown clay mottled with dark gray clay. | | | |
| | 30 | | | | | |
| | | | Twigs | | | |
| | 40 | | Medium brown clay. | | | |
| | 50 | | | | | |
| | | | Reddish medium brown clay. | | | |
| | 60 | | | | | |
| | 70 | | | | | |

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. | PROJECT | HOLE NO.

Hole No.

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 1 of 2 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT Sargent Beach, TX | 10. SIZE AND TYPE OF BIT |
| 2. LOCATION (Coordinates or Station) Overwash | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 3. DRILLING AGENCY | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) HA-S2-1 | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN : DISTURBED : UNDISTURBED |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT. | 15. ELEVATION GROUND WATER |
| | 16. DATE HOLE : STARTED 11-20-90 : COMPLETED ——— |
| 7. THICKNESS OF OVERBURDEN | 17. ELEVATION TOP OF HOLE |
| 8. DEPTH DRILLED INTO ROCK | 18. TOTAL CORE RECOVERY FOR BORING % |
| 9. TOTAL DEPTH OF HOLE 196 cm | 19. SIGNATURE OF INSPECTOR |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| | | | Light tan shelley sand. | | | |
| | 10 | | | | | |
| | 20 | | Iron stained tan shelley sand with pebbles. | | | |
| | 30 | | | | | |
| | 40 | | Light grayish tan shelley sand. | | | |
| | 50 | | | | | |
| | 60 | | Dark brown clay mottled with black clay. | | | |
| | 70 | | | | | |
| | 80 | | Medium to dark brown clay. | | | |
| | 90 | | Reddish medium to dark brown clay. | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. | PROJECT | HOLE NO.

**DRILLING LOG (Cont Sheet)** ELEVATION TOP OF HOLE | **Hole No.** HA-S2-1

PROJECT: Sargent Beach, TX | INSTALLATION: Overwash | SHEET 2 OF 2 SHEETS

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| | 100 | | | | | |
| | | | Reddish medium to dark brown clay. | | | |
| | 110 | | | | | |
| | 120 | | | | | |
| | | | Dark gray clay mottled with medium to dark brown clay. | | | |
| | 130 | | Brownish dark gray clay. | | | |
| | 140 | | Dark gray clay mottled with black clay. | | | |
| | 150 | | | | | |
| | 160 | | Red iron staining. | | | |
| | | | Yellow iron staining. | | | |
| | 170 | | | | | |
| | 180 | | | | | |
| | | | Yellowish light to medium gray clay. | | | |
| | 190 | | | | | |
| | 200 | | | | | |

ENG FORM 1836-A (ER 1110-1-1801) | PROJECT | HOLE NO.

Hole No.

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 1 OF 2 SHEETS |
|---|---|---|---|

1. PROJECT: Sargent Beach, TX
2. LOCATION (Coordinates or Station): Berm Crest
3. DRILLING AGENCY:
4. HOLE NO. (As shown on drawing title and file number): HA-S2-2
5. NAME OF DRILLER:
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN:
8. DEPTH DRILLED INTO ROCK:
9. TOTAL DEPTH OF HOLE: 195.5 cm
10. SIZE AND TYPE OF BIT:
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL:
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
14. TOTAL NUMBER CORE BOXES:
15. ELEVATION GROUND WATER:
16. DATE HOLE: STARTED 11-20-90 COMPLETED ——
17. ELEVATION TOP OF HOLE:
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: SLL

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| | 0 | | Tan to light brown and medium gray shell hash with pebbles. | | | |
| | 17 | | Poorly sorted tan sand with large shell fragments. | | | |
| | 35 | | Clay ball | | | |
| | 44 | | Poorly sorted tan sand with abundance of shell fragments. | | | |
| | 75 | | Shelly sand mottled with dark brown clay. | | | |
| | 90 | | Reddish medium brown clay. | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE | Hole No. HA-S2-2

PROJECT: Sargent Beach, TX | INSTALLATION: Berm Crest | SHEET 2 OF 2 SHEETS

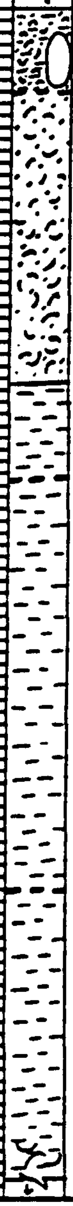
| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOV-ERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| | 100 | | Tar ball | | | |
| | | | Medium brown clay. | | | |
| | 110 | | | | | |
| | 120 | | | | | |
| | 130 | | Dark brown clay mottled with black clay. | | | |
| | 140 | | | | | |
| | 150 | | | | | |
| | 160 | | | | | |
| | 170 | | Medium gray clay mottled with yellow clay. | | | |
| | 180 | | | | | |
| | 190 | | Dark gray clay. | | | |
| | 200 | | | | | |

ENG FORM 1836-A (ER 1110-1-1801) | PROJECT | HOLE NO.

Hole No.

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 1 of 2 SHEETS |
|---|---|---|---|
| 1. PROJECT Sargent Beach, TX | | 10. SIZE AND TYPE OF BIT | |
| 2. LOCATION (Coordinates or Station) Mid-tide | | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) | |
| 3. DRILLING AGENCY | | 12. MANUFACTURER'S DESIGNATION OF DRILL | |
| 4. HOLE NO. (As shown on drawing title and file number) HA-S2-3 | | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN : DISTURBED : UNDISTURBED | |
| 5. NAME OF DRILLER | | 14. TOTAL NUMBER CORE BOXES | |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | | 15. ELEVATION GROUND WATER | |
| 7. THICKNESS OF OVERBURDEN | | 16. DATE HOLE : STARTED 11-20-90 : COMPLETED ---- | |
| 8. DEPTH DRILLED INTO ROCK | | 17. ELEVATION TOP OF HOLE | |
| 9. TOTAL DEPTH OF HOLE 195 cm | | 18. TOTAL CORE RECOVERY FOR BORING % | |
| | | 19. SIGNATURE OF INSPECTOR GRL | |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| | | | Clay ball — Brown sandy shell hash with abundance of pebbles with medium brown clay. | | | |
| | 10 | | | | | |
| | | | Tan to brown sandy shell hash with pebbles. | | | |
| | 20 | | | | | |
| | 30 | | | | | |
| | | | Medium to dark brown clay. | | | |
| | 40 | | | | | |
| | 50 | | | | | |
| | | | Medium reddish brown clay. | | | |
| | 60 | | | | | |
| | 70 | | | | | |
| | | | Medium to dark grayish brown clay mottled with medium reddish brown clay with few shell fragments. | | | |
| | 80 | | | | | |
| | 90 | | | | | |



ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. | PROJECT | HOLE NO.

| DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE | | Hole No. HA-S2-3 |
|---|---|---|---|
| PROJECT Sargent Beach, TX | INSTALLATION Mid-tide | | SHEET 2 OF 2 SHEETS |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| | 100 | | Grayish dark brown clay. | | | |
| | | | Dark gray clay mottled with dark brown clay. | | | |
| | 110 | | | | | |
| | 120 | | Medium to dark brown clay. | | | |
| | 130 | | | | | |
| | 140 | | | | | |
| | 150 | | Dark gray clay mottled with black clay. | | | |
| | 160 | | | | | |
| | | | Yellowish medium to light gray clay. | | | |
| | 170 | | | | | |
| | | | Yellowish medium to dark clay mottled with black clay. | | | |
| | 180 | | | | | |
| | 190 | | Yellowish medium to dark gray clay. | | | |
| | 200 | | | | | |

ENG FORM 1836-A (EM 1110-1-1801) | PROJECT | HOLE NO.

Hole No.

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 1 OF 1 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT Sargent Beach, TX | 10. SIZE AND TYPE OF BIT |
| 2. LOCATION (Coordinates or Station) Cedar Lakes High tide | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 3. DRILLING AGENCY | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) HA C3 | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT. | 15. ELEVATION GROUND WATER |
| | 16. DATE HOLE — STARTED 11-19-90 — COMPLETED —— |
| 7. THICKNESS OF OVERBURDEN | 17. ELEVATION TOP OF HOLE |
| 8. DEPTH DRILLED INTO ROCK | 18. TOTAL CORE RECOVERY FOR BORING % |
| 9. TOTAL DEPTH OF HOLE 32 cm | 19. SIGNATURE OF INSPECTOR |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| | 10 | | Light brown sand with some shell fragments. | | | |
| | 20 | | | | | |
| | 30 | | | | | |
| | 40 | | | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No.

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 1 OF 1 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT Sargent Beach, TX | 10. SIZE AND TYPE OF BIT |
| 2. LOCATION (Coordinates or Station) Cedar Lakes Mid-tide | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 3. DRILLING AGENCY | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) C2 - A1 core | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES |
| 6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER |
| | 16. DATE HOLE: STARTED 11-19-90 / COMPLETED —— |
| 7. THICKNESS OF OVERBURDEN | 17. ELEVATION TOP OF HOLE |
| 8. DEPTH DRILLED INTO ROCK | 18. TOTAL CORE RECOVERY FOR BORING % |
| 9. TOTAL DEPTH OF HOLE 27 cm | 19. SIGNATURE OF INSPECTOR CRL |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| | | | Light brown sand with few shell fragments. Few large shell fragments. | | | |
| | 10 | | Light brown shelley sand with few large shell fragments. | | | |
| | | Twigs | Medium brown sand with abundance of shell fragments. | | | |
| | 20 | Roots | Medium to dark brown sand mottled with dark gray clay. | | | |
| | 30 | | | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. | PROJECT | HOLE NO.

Hole No.

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 1 OF 1 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT: Sargent Beach, TX | 10. SIZE AND TYPE OF BIT |
| 2. LOCATION (Coordinates or Station): Cedar Lakes — Swash zone | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 3. DRILLING AGENCY | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number): C1 - A1 core | 13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES |
| 6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER |
| | 16. DATE HOLE — STARTED: 11-19-90 — COMPLETED: —— |
| 7. THICKNESS OF OVERBURDEN | 17. ELEVATION TOP OF HOLE |
| 8. DEPTH DRILLED INTO ROCK | 18. TOTAL CORE RECOVERY FOR BORING % |
| 9. TOTAL DEPTH OF HOLE: 37.5 cm | 19. SIGNATURE OF INSPECTOR |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| | | | Medium brown sand with abundance of shells mottled with dark gray clay. | | | |
| | 10 | | Medium brown sand mottled with dark gray clay. | | | |
| | | | Medium brown sand. | | | |
| | 20 | | Medium gray sandy clay. | | | |
| | | | Mottled with dark gray clay. | | | |
| | 30 | | | | | |
| | 40 | | | | | |

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. | PROJECT | HOLE NO.

# Appendix B
# Sediment Grain Size Statistics

Appendix B lists the coarse grained size statistical data of the sediment samples that were collected for this study. The sediment samples consist of surface grab samples, two hand auger core samples, and one sample which was analyzed for its fine grain size distribution. The fine grain size percentages were determined by using the pipet method. The computer program ISAP (Interactive Sediment Analysis Program) was used to obtain all statistics. Surface sediment samples were taken near the overwash fan, at the high water line, mid-tide, and low-tide areas. Composites of the berm crest, mid-tide, and low-tide samples were mathematically calculated with the ISAP program in order to reduce cross-shore variability. The sample content by weight percent of the main grain size classes, gravel, coarse sand, medium sand, fine sand, silt, and clay are listed. The standard statistics of the collected samples include median grain size in phi and mm units, mean grain size in phi and mm units, standard deviation in phi units, Skewness in phi units, and Kurtosis in phi units.

## SARGENT BEACH SEDIMENT ANALYSIS

| Locality | Type | Sample | Date | Profile | Analysis Date | Analyzer |
|---|---|---|---|---|---|---|
| SB | GRAB | 1 | 11/19/90 | | 1/30/91 | CLK |

X Position : Y Position :

Elevation of Top of Core :
Length of Core :
Depth to Top of Sample :
Depth to Bottom of Sample :

Comments : CEDAR LAKES BERM LARGE SHELL HASH

Start Weight : 15.436 Final Weight : 15.327 Deviation : 0.706 %.

| PHI | MM | Weight | Percnt | Cumul Percnt | : | PHI | MM | Weight | Percnt | Cumul Percnt |
|---|---|---|---|---|---|---|---|---|---|---|
| -2.25 | 4.757 | 0.000 | 0.000 | 0.000 | : | 1.25 | 0.420 | 0.178 | 1.161 | 14.732 |
| -2.00 | 4.000 | 1.221 | 7.966 | 7.966 | : | 1.50 | 0.354 | 0.178 | 1.161 | 15.894 |
| -1.75 | 3.364 | 0.072 | 0.470 | 8.436 | : | 1.75 | 0.297 | 0.492 | 3.210 | 19.104 |
| -1.50 | 2.828 | 0.050 | 0.326 | 8.762 | : | 2.00 | 0.250 | 1.756 | 11.457 | 30.560 |
| -1.25 | 2.378 | 0.134 | 0.874 | 9.637 | : | 2.25 | 0.210 | 3.248 | 21.191 | 51.752 |
| -1.00 | 2.000 | 0.023 | 0.150 | 9.787 | : | 2.50 | 0.177 | 3.413 | 22.268 | 74.020 |
| -0.75 | 1.682 | 0.033 | 0.215 | 10.002 | : | 2.75 | 0.149 | 1.936 | 12.631 | 86.651 |
| -0.50 | 1.414 | 0.040 | 0.261 | 10.263 | : | 3.00 | 0.125 | 1.147 | 7.484 | 94.135 |
| -0.25 | 1.189 | 0.050 | 0.326 | 10.589 | : | 3.25 | 0.105 | 0.713 | 4.652 | 98.786 |
| 0.00 | 1.000 | 0.048 | 0.313 | 10.902 | : | 3.50 | 0.088 | 0.122 | 0.796 | 99.582 |
| 0.25 | 0.841 | 0.069 | 0.450 | 11.353 | : | 3.75 | 0.074 | 0.044 | 0.287 | 99.870 |
| 0.50 | 0.707 | 0.093 | 0.607 | 11.959 | : | 4.00 | 0.063 | 0.011 | 0.072 | 99.941 |
| 0.75 | 0.595 | 0.101 | 0.659 | 12.618 | : | 4.25 | 0.053 | 0.009 | 0.059 | 100.000 |
| 1.00 | 0.500 | 0.146 | 0.953 | 13.571 | : | | | | | |

Sample Content by Weight Percent :

| | Gravel | Sand coarse | Sand medium | Sand fine | Silt | Clay |
|---|---|---|---|---|---|---|
| Wentworth Classification | 9.787 | 3.784 | 16.990 | 69.381 | 0.059 | 0.000 |
| Unified Classification | 0.000 | 9.787 | 4.946 | 85.137 | 0.130 | 0.000 |

Standard Statistics :

| | Median | Mean | Dev. | Skew | Kurt |
|---|---|---|---|---|---|
| Method of Moments (PHI) | | 1.82 | 1.39 | -2.04 | 6.09 |
| Folk Graphic Measures (PHI) | 2.23 | 2.15 | 1.08 | -0.45 | 3.29 |
| Grain Size (mm) | 0.21 | 0.28 | | | |

## SARGENT BEACH SEDIMENT ANALYSIS

| Locality | Type | Sample | Date | Profile | Analysis Date | Analyzer |
|---|---|---|---|---|---|---|
| SB | GRAB | 2 | 11/19/90 | | 1/30/91 | CLK |

X Position :  Y Position :

Elevation of Top of Core :
Length of Core :
Depth to Top of Sample :
Depth to Bottom of Sample :

Comments : CEDAR LAKES MID-TIDE LARGE SHELL HASH IN SAMPLE

Start Weight : 22.849  Final Weight : 22.847  Deviation : 0.009 %

| PHI | MM | Weight | Percnt | Cumul Percnt | PHI | MM | Weight | Percnt | Cumul Percnt |
|---|---|---|---|---|---|---|---|---|---|
| -2.25 | 4.757 | 0.000 | 0.000 | 0.000 | 1.25 | 0.420 | 0.126 | 0.551 | 4.211 |
| -2.00 | 4.000 | 0.174 | 0.762 | 0.762 | 1.50 | 0.354 | 0.180 | 0.788 | 4.998 |
| -1.75 | 3.364 | 0.001 | 0.004 | 0.766 | 1.75 | 0.297 | 0.563 | 2.464 | 7.463 |
| -1.50 | 2.828 | 0.096 | 0.420 | 1.186 | 2.00 | 0.250 | 1.883 | 8.242 | 15.704 |
| -1.25 | 2.378 | 0.038 | 0.166 | 1.352 | 2.25 | 0.210 | 3.178 | 13.910 | 29.614 |
| -1.00 | 2.000 | 0.030 | 0.131 | 1.484 | 2.50 | 0.177 | 3.816 | 16.702 | 46.317 |
| -0.75 | 1.682 | 0.043 | 0.188 | 1.672 | 2.75 | 0.149 | 3.419 | 14.965 | 61.282 |
| -0.50 | 1.414 | 0.020 | 0.088 | 1.760 | 3.00 | 0.125 | 3.944 | 17.263 | 78.544 |
| -0.25 | 1.189 | 0.023 | 0.101 | 1.860 | 3.25 | 0.105 | 4.054 | 17.744 | 96.288 |
| 0.00 | 1.000 | 0.033 | 0.144 | 2.005 | 3.50 | 0.088 | 0.702 | 3.073 | 99.361 |
| 0.25 | 0.841 | 0.070 | 0.306 | 2.311 | 3.75 | 0.074 | 0.126 | 0.551 | 99.912 |
| 0.50 | 0.707 | 0.051 | 0.223 | 2.534 | 4.00 | 0.063 | 0.014 | 0.061 | 99.974 |
| 0.75 | 0.595 | 0.079 | 0.346 | 2.880 | 4.25 | 0.053 | 0.006 | 0.026 | 100.000 |
| 1.00 | 0.500 | 0.178 | 0.779 | 3.659 | | | | | |

Sample Content by Weight Percent :

| | Gravel | Sand coarse | Sand medium | Sand fine | Silt | Clay |
|---|---|---|---|---|---|---|
| Wentworth Classification | 1.484 | 2.175 | 12.045 | 84.269 | 0.026 | 0.000 |
| Unified Classification | 0.000 | 1.484 | 2.727 | 95.702 | 0.088 | 0.000 |

Standard Statistics :

| | Median | Mean | Dev. | Skew | Kurt |
|---|---|---|---|---|---|
| Method of Moments (PHI) | | 2.46 | 0.78 | -2.94 | 16.06 |
| Folk Graphic Measures (PHI) | 2.56 | 2.55 | 0.53 | -0.13 | 0.91 |
| Grain Size (mm) | 0.17 | 0.18 | | | |

## SARGENT BEACH SEDIMENT ANALYSIS

| Locality | Type | Sample | Date | Profile | Analysis Date | Analyzer |
|---|---|---|---|---|---|---|
| SB | GRAB | 3 | 11/19/90 | | 1/30/91 | CLK |

X Position :                Y Position :

Elevation of Top of Core :
Length of Core :
Depth to Top of Sample :
Depth to Bottom of Sample :

Comments : CEDAR LAKES LOW-TIDE

Start Weight : 16.628   Final Weight : 16.616   Deviation : 0.072 %

| PHI | MM | Weight | Percnt | Cumul Percnt | PHI | MM | Weight | Percnt | Cumul Percnt |
|---|---|---|---|---|---|---|---|---|---|
| -2.25 | 4.757 | 0.000 | 0.000 | 0.000 | 1.25 | 0.420 | 0.040 | 0.241 | 9.924 |
| -2.00 | 4.000 | 0.533 | 3.208 | 3.208 | 1.50 | 0.354 | 0.044 | 0.265 | 10.189 |
| -1.75 | 3.364 | 0.123 | 0.740 | 3.948 | 1.75 | 0.297 | 0.092 | 0.554 | 10.743 |
| -1.50 | 2.828 | 0.140 | 0.843 | 4.791 | 2.00 | 0.250 | 0.258 | 1.553 | 12.295 |
| -1.25 | 2.378 | 0.136 | 0.818 | 5.609 | 2.25 | 0.210 | 0.552 | 3.322 | 15.617 |
| -1.00 | 2.000 | 0.105 | 0.632 | 6.241 | 2.50 | 0.177 | 1.107 | 6.662 | 22.280 |
| -0.75 | 1.682 | 0.078 | 0.469 | 6.710 | 2.75 | 0.149 | 1.682 | 10.123 | 32.403 |
| -0.50 | 1.414 | 0.113 | 0.680 | 7.390 | 3.00 | 0.125 | 3.705 | 22.298 | 54.700 |
| -0.25 | 1.189 | 0.072 | 0.433 | 7.824 | 3.25 | 0.105 | 5.650 | 34.003 | 88.704 |
| 0.00 | 1.000 | 0.059 | 0.355 | 8.179 | 3.50 | 0.088 | 1.540 | 9.268 | 97.972 |
| 0.25 | 0.841 | 0.084 | 0.506 | 8.684 | 3.75 | 0.074 | 0.296 | 1.781 | 99.753 |
| 0.50 | 0.707 | 0.049 | 0.295 | 8.979 | 4.00 | 0.063 | 0.030 | 0.181 | 99.934 |
| 0.75 | 0.595 | 0.051 | 0.307 | 9.286 | 4.25 | 0.053 | 0.011 | 0.066 | 100.000 |
| 1.00 | 0.500 | 0.066 | 0.397 | 9.683 | | | | | |

Sample Content by Weight Percent :

| | Gravel | Sand coarse | Sand medium | Sand fine | Silt | Clay |
|---|---|---|---|---|---|---|
| Wentworth Classification | 6.241 | 3.442 | 2.612 | 87.638 | 0.066 | 0.000 |
| Unified Classification | 0.000 | 6.241 | 3.683 | 89.829 | 0.247 | 0.000 |

Standard Statistics :

| | Median | Mean | Dev. | Skew | Kurt |
|---|---|---|---|---|---|
| Method of Moments (PHI) | | 2.51 | 1.31 | -2.57 | 8.64 |
| Folk Graphic Measures (PHI) | 2.95 | 2.81 | 0.97 | -0.62 | 3.42 |
| Grain Size (mm) | 0.13 | 0.18 | | | |

SARGENT BEACH SEDIMENT ANLYSIS

| Locality | Type | Sample | Date | Profile | Analysis Date | Analyzer |
|---|---|---|---|---|---|---|
| SB | GRAB | 4 | 11/19/90 | | 1/30/91 | CLK |

X Position :　　　　Y Position :

Elevation of Top of Core :
Length of Core :
Depth to Top of Sample :
Depth to Bottom of Sample :

Comments : S-2 OVERWASH LOTS OF SHELL HASH

Start Weight : 29.073　Final Weight : 29.030　Deviation : 0.148 %

| PHI | MM | Weight | Percnt | Cumul Percnt | PHI | MM | Weight | Percnt | Cumul Percnt |
|---|---|---|---|---|---|---|---|---|---|
| -2.25 | 4.757 | 0.000 | 0.000 | 0.000 | 1.25 | 0.420 | 0.422 | 1.454 | 35.808 |
| -2.00 | 4.000 | 2.380 | 8.198 | 8.198 | 1.50 | 0.354 | 0.406 | 1.399 | 37.206 |
| -1.75 | 3.364 | 0.297 | 1.023 | 9.221 | 1.75 | 0.297 | 0.975 | 3.359 | 40.565 |
| -1.50 | 2.828 | 0.757 | 2.608 | 11.829 | 2.00 | 0.250 | 2.645 | 9.111 | 49.676 |
| -1.25 | 2.378 | 0.903 | 3.111 | 14.940 | 2.25 | 0.210 | 4.195 | 14.451 | 64.127 |
| -1.00 | 2.000 | 0.618 | 2.129 | 17.069 | 2.50 | 0.177 | 4.352 | 14.991 | 79.118 |
| -0.75 | 1.682 | 0.371 | 1.278 | 18.347 | 2.75 | 0.149 | 2.974 | 10.245 | 89.363 |
| -0.50 | 1.414 | 0.764 | 2.632 | 20.978 | 3.00 | 0.125 | 1.700 | 5.856 | 95.219 |
| -0.25 | 1.189 | 0.708 | 2.439 | 23.417 | 3.25 | 0.105 | 0.895 | 3.083 | 98.302 |
| 0.00 | 1.000 | 0.542 | 1.867 | 25.284 | 3.50 | 0.088 | 0.290 | 0.999 | 99.301 |
| 0.25 | 0.841 | 0.695 | 2.394 | 27.678 | 3.75 | 0.074 | 0.143 | 0.493 | 99.793 |
| 0.50 | 0.707 | 0.551 | 1.898 | 29.576 | 4.00 | 0.063 | 0.040 | 0.138 | 99.931 |
| 0.75 | 0.595 | 0.567 | 1.953 | 31.529 | 4.25 | 0.053 | 0.020 | 0.069 | 100.000 |
| 1.00 | 0.500 | 0.820 | 2.825 | 34.354 | | | | | |

Sample Content by Weight Percent :

| | Gravel | Sand coarse | Sand medium | Sand fine | Silt | Clay |
|---|---|---|---|---|---|---|
| Wentworth Classification | 17.069 | 17.286 | 15.322 | 50.255 | 0.069 | 0.000 |
| Unified Classification | 0.000 | 17.069 | 18.739 | 63.986 | 0.207 | 0.000 |

Standard Statistics :

| | Median | Mean | Dev. | Skew | Kurt |
|---|---|---|---|---|---|
| Method of Moments (PHI) | | 1.22 | 1.67 | -0.85 | 2.33 |
| Folk Graphic Measures (PHI) | 2.01 | 1.17 | 1.71 | -0.64 | -0.84 |
| Grain Size (mm) | 0.25 | 0.43 | | | |

**SARGENT BEACH SEDIMENT ANALYSIS**

| Locality | Type | Sample | Date | Profile | Analysis Date | Analyzer |
|---|---|---|---|---|---|---|
| SB | GRAB | 5 | 11/19/90 | | 1/30/91 | CLK |

X Position :    Y Position :

Elevation of Top of Core :
Length of Core :
Depth to Top of Sample :
Depth to Bottom of Sample :

Comments : S-2 BERM

Start Weight : 17.360   Final Weight : 17.248   Deviation : 0.645 %

| PHI | MM | Weight | Percnt | Cumul Percnt | : | PHI | MM | Weight | Percnt | Cumul Percnt |
|---|---|---|---|---|---|---|---|---|---|---|
| -2.25 | 4.757 | 0.000 | 0.000 | 0.000 | : | 1.25 | 0.420 | 0.133 | 0.771 | 4.545 |
| -2.00 | 4.000 | 0.000 | 0.000 | 0.000 | : | 1.50 | 0.354 | 0.140 | 0.812 | 5.357 |
| -1.75 | 3.364 | 0.002 | 0.012 | 0.012 | : | 1.75 | 0.297 | 0.336 | 1.948 | 7.305 |
| -1.50 | 2.828 | 0.095 | 0.551 | 0.562 | : | 2.00 | 0.250 | 1.430 | 8.291 | 15.596 |
| -1.25 | 2.378 | 0.036 | 0.209 | 0.771 | : | 2.25 | 0.210 | 3.497 | 20.275 | 35.871 |
| -1.00 | 2.000 | 0.057 | 0.330 | 1.102 | : | 2.50 | 0.177 | 4.932 | 28.595 | 64.465 |
| -0.75 | 1.682 | 0.081 | 0.470 | 1.571 | : | 2.75 | 0.149 | 3.324 | 19.272 | 83.737 |
| -0.50 | 1.414 | 0.055 | 0.319 | 1.890 | : | 3.00 | 0.125 | 1.813 | 10.511 | 94.249 |
| -0.25 | 1.189 | 0.031 | 0.180 | 2.070 | : | 3.25 | 0.105 | 0.719 | 4.169 | 98.417 |
| 0.00 | 1.000 | 0.032 | 0.186 | 2.255 | : | 3.50 | 0.088 | 0.158 | 0.916 | 99.333 |
| 0.25 | 0.841 | 0.054 | 0.313 | 2.568 | : | 3.75 | 0.074 | 0.081 | 0.470 | 99.803 |
| 0.50 | 0.707 | 0.048 | 0.278 | 2.847 | : | 4.00 | 0.063 | 0.020 | 0.116 | 99.919 |
| 0.75 | 0.595 | 0.055 | 0.319 | 3.166 | : | 4.25 | 0.053 | 0.014 | 0.081 | 100.000 |
| 1.00 | 0.500 | 0.105 | 0.609 | 3.774 | : | | | | | |

Sample Content by Weight Percent :

| | Gravel | Sand coarse | Sand medium | Sand fine | Silt | Clay |
|---|---|---|---|---|---|---|
| Wentworth Classification | 1.102 | 2.673 | 11.822 | 84.323 | 0.081 | 0.000 |
| Unified Classification | 0.000 | 1.102 | 3.444 | 95.257 | 0.197 | 0.000 |

Standard Statistics :

| | Median | Mean | Dev. | Skew | Kurt |
|---|---|---|---|---|---|
| Method of Moments (PHI) | | 2.30 | 0.68 | -2.92 | 15.86 |
| Folk Graphic Measures (PHI) | 2.37 | 2.38 | 0.44 | -0.08 | 1.30 |
| Grain Size (mm) | 0.19 | 0.20 | | | |

## SARGENT BEACH SEDIMENT ANALYSIS

| Locality | Type | Sample | Date | Profile | Analysis Date | Analyzer |
|---|---|---|---|---|---|---|
| SB | GRAB | 6 | 11/19/90 | | 1/30/91 | CLK |

X Position :  Y Position :

Elevation of Top of Core :
Length of Core :
Depth to Top of Sample :
Depth to Bottom of Sample :

Comments : S-2 MID-TIDE LOTS OF SMALL SHELL HASH

Start Weight : 34.610 Final Weight : 34.585 Deviation : 0.072 %

| PHI | MM | Weight | Percnt | Cumul Percnt | PHI | MM | Weight | Percnt | Cumul Percnt |
|---|---|---|---|---|---|---|---|---|---|
| -2.25 | 4.757 | 0.000 | 0.000 | 0.000 | 1.25 | 0.420 | 0.243 | 0.703 | 51.615 |
| -2.00 | 4.000 | 1.763 | 5.098 | 5.098 | 1.50 | 0.354 | 0.192 | 0.555 | 52.170 |
| -1.75 | 3.364 | 0.874 | 2.527 | 7.625 | 1.75 | 0.297 | 0.397 | 1.148 | 53.318 |
| -1.50 | 2.828 | 1.085 | 3.137 | 10.762 | 2.00 | 0.250 | 1.119 | 3.236 | 56.553 |
| -1.25 | 2.378 | 1.125 | 3.253 | 14.015 | 2.25 | 0.210 | 2.524 | 7.298 | 63.851 |
| -1.00 | 2.000 | 1.141 | 3.299 | 17.314 | 2.50 | 0.177 | 4.534 | 13.110 | 76.961 |
| -0.75 | 1.682 | 1.828 | 5.286 | 22.599 | 2.75 | 0.149 | 4.257 | 12.309 | 89.270 |
| -0.50 | 1.414 | 2.349 | 6.792 | 29.391 | 3.00 | 0.125 | 2.647 | 7.654 | 96.924 |
| -0.25 | 1.189 | 2.353 | 6.804 | 36.195 | 3.25 | 0.105 | 0.906 | 2.620 | 99.543 |
| 0.00 | 1.000 | 1.531 | 4.427 | 40.622 | 3.50 | 0.088 | 0.104 | 0.301 | 99.844 |
| 0.25 | 0.841 | 1.457 | 4.213 | 44.834 | 3.75 | 0.074 | 0.036 | 0.104 | 99.948 |
| 0.50 | 0.707 | 0.888 | 2.568 | 47.402 | 4.00 | 0.063 | 0.010 | 0.029 | 99.977 |
| 0.75 | 0.595 | 0.601 | 1.738 | 49.140 | 4.25 | 0.053 | 0.008 | 0.023 | 100.000 |
| 1.00 | 0.500 | 0.613 | 1.772 | 50.912 | | | | | |

Sample Content by Weight Percent :

| | Gravel | Sand coarse | Sand medium | Sand fine | Silt | Clay |
|---|---|---|---|---|---|---|
| Wentworth Classification | 17.314 | 33.598 | 5.641 | 43.423 | 0.023 | 0.000 |
| Unified Classification | 0.000 | 17.314 | 34.301 | 48.333 | 0.052 | 0.000 |

Standard Statistics :

| | Median | Mean | Dev. | Skew | Kurt |
|---|---|---|---|---|---|
| Method of Moments (PHI) | | 0.84 | 1.71 | -0.22 | 1.52 |
| Folk Graphic Measures (PHI) | 0.87 | 0.80 | 1.68 | -0.11 | 0.65 |
| Grain Size (mm) | 0.55 | 0.56 | | | |

## SARGENT BEACH SEDIMENT ANALYSIS

| Locality | Type | Sample | Date | Profile | Analysis Date | Analyzer |
|---|---|---|---|---|---|---|
| SB | GRAB | 7 | 11/19/90 | | 1/30/91 | CLK |

X Position :  Y Position :

Elevation of Top of Core :
Length of Core :
Depth to Top of Sample :
Depth to Bottom of Sample :

Comments : S-2 LOW-TIDE LOTS OF SMALL SHELL HASH

Start Weight : 28.848 Final Weight : 28.815 Deviation : 0.114 %

| PHI | MM | Weight | Percnt | Cumul Percnt | PHI | MM | Weight | Percnt | Cumul Percnt |
|---|---|---|---|---|---|---|---|---|---|
| -2.25 | 4.757 | 0.000 | 0.000 | 0.000 | 1.25 | 0.420 | 0.194 | 0.673 | 51.449 |
| -2.00 | 4.000 | 3.238 | 11.237 | 11.237 | 1.50 | 0.354 | 0.154 | 0.534 | 51.983 |
| -1.75 | 3.364 | 1.120 | 3.887 | 15.124 | 1.75 | 0.297 | 0.244 | 0.847 | 52.830 |
| -1.50 | 2.828 | 1.105 | 3.835 | 18.959 | 2.00 | 0.250 | 0.490 | 1.701 | 54.531 |
| -1.25 | 2.378 | 1.153 | 4.001 | 22.960 | 2.25 | 0.210 | 0.932 | 3.234 | 57.765 |
| -1.00 | 2.000 | 1.560 | 5.414 | 28.374 | 2.50 | 0.177 | 1.835 | 6.368 | 64.133 |
| -0.75 | 1.682 | 1.037 | 3.599 | 31.973 | 2.75 | 0.149 | 2.964 | 10.286 | 74.420 |
| -0.50 | 1.414 | 1.451 | 5.036 | 37.009 | 3.00 | 0.125 | 3.926 | 13.625 | 88.044 |
| -0.25 | 1.189 | 0.944 | 3.276 | 40.285 | 3.25 | 0.105 | 2.841 | 9.859 | 97.904 |
| 0.00 | 1.000 | 0.694 | 2.408 | 42.693 | 3.50 | 0.088 | 0.489 | 1.697 | 99.601 |
| 0.25 | 0.841 | 0.841 | 2.919 | 45.612 | 3.75 | 0.074 | 0.099 | 0.344 | 99.944 |
| 0.50 | 0.707 | 0.526 | 1.825 | 47.437 | 4.00 | 0.063 | 0.011 | 0.038 | 99.983 |
| 0.75 | 0.595 | 0.464 | 1.610 | 49.047 | 4.25 | 0.053 | 0.005 | 0.017 | 100.000 |
| 1.00 | 0.500 | 0.498 | 1.728 | 50.776 | | | | | |

Sample Content by Weight Percent :

| | Gravel | Sand coarse | Sand medium | Sand fine | Silt | Clay |
|---|---|---|---|---|---|---|
| Wentworth Classification | 28.374 | 22.402 | 3.755 | 45.452 | 0.017 | 0.000 |
| Unified Classification | 0.000 | 28.374 | 23.075 | 48.496 | 0.056 | 0.000 |

Standard Statistics :

| | Median | Mean | Dev. | Skew | Kurt |
|---|---|---|---|---|---|
| Method of Moments (PHI) | | 0.79 | 2.00 | -0.17 | 1.37 |
| Folk Graphic Measures (PHI) | 0.89 | 0.71 | 1.96 | -0.13 | 0.56 |
| Grain Size (mm) | 0.54 | 0.58 | | | |

## SARGENT BEACH SEDIMENT ANALYSIS

| Locality | Type | Sample | Date | Profile | Analysis Date | Analyzer |
|---|---|---|---|---|---|---|
| SB | GRAB | 8 | 11/20/90 | | 1/30/91 | CLK |

X Position :                Y Position :

Elevation of Top of Core :
Length of Core :
Depth to Top of Sample :
Depth to Bottom of Sample :

Comments : S-4 OVERWASH

Start Weight : 31.094   Final Weight : 30.999   Deviation : 0.306 %

| PHI | MM | Weight | Percnt | Cumul Percnt | : | PHI | MM | Weight | Percnt | Cumul Percnt |
|---|---|---|---|---|---|---|---|---|---|---|
| -2.25 | 4.757 | 0.000 | 0.000 | 0.000 | : | 1.25 | 0.420 | 0.590 | 1.903 | 13.723 |
| -2.00 | 4.000 | 0.224 | 0.723 | 0.723 | : | 1.50 | 0.354 | 0.665 | 2.145 | 15.868 |
| -1.75 | 3.364 | 0.060 | 0.194 | 0.91[illegible] | : | 1.75 | 0.297 | 1.595 | 5.145 | 21.014 |
| -1.50 | 2.828 | 0.019 | 0.061 | 0.977 | : | 2.00 | 0.250 | 4.806 | 15.504 | 36.517 |
| -1.25 | 2.378 | 0.124 | 0.400 | 1.377 | : | 2.25 | 0.210 | 7.193 | 23.204 | 59.721 |
| -1.00 | 2.000 | 0.133 | 0.429 | 1.807 | : | 2.50 | 0.177 | 6.688 | 21.575 | 81.296 |
| -0.75 | 1.682 | 0.088 | 0.284 | 2.090 | : | 2.75 | 0.149 | 3.391 | 10.939 | 92.235 |
| -0.50 | 1.414 | 0.178 | 0.574 | 2.665 | : | 3.00 | 0.125 | 1.450 | 4.678 | 96.913 |
| -0.25 | 1.189 | 0.267 | 0.861 | 3.526 | : | 3.25 | 0.105 | 0.583 | 1.881 | 98.794 |
| 0.00 | 1.000 | 0.257 | 0.829 | 4.355 | : | 3.50 | 0.088 | 0.190 | 0.613 | 99.406 |
| 0.25 | 0.841 | 0.432 | 1.394 | 5.749 | : | 3.75 | 0.074 | 0.116 | 0.374 | 99.781 |
| 0.50 | 0.707 | 0.456 | 1.471 | 7.220 | : | 4.00 | 0.063 | 0.042 | 0.135 | 99.916 |
| 0.75 | 0.595 | 0.522 | 1.684 | 8.904 | : | 4.25 | 0.053 | 0.026 | 0.084 | 100.000 |
| 1.00 | 0.500 | 0.904 | 2.916 | 11.820 | : | | | | | |

Sample Content by Weight Percent :

| | Gravel | Sand coarse | Sand medium | Sand fine | Silt | Clay |
|---|---|---|---|---|---|---|
| Wentworth Classification | 1.807 | 10.013 | 24.698 | 63.399 | 0.084 | 0.000 |
| Unified Classification | 0.000 | 1.807 | 11.917 | 86.058 | 0.219 | 0.000 |

Standard Statistics :

| | Median | Mean | Dev. | Skew | Kurt |
|---|---|---|---|---|---|
| Method of Moments (PHI) | | 1.96 | 0.87 | -2.03 | 8.52 |
| Folk Graphic Measures (PHI) | 2.15 | 2.07 | 0.69 | -0.33 | 1.86 |
| Grain Size (mm) | 0.23 | 0.26 | | | |

## SARGENT BEACH SEDIMENT ANALYSIS

| Locality | Type | Sample | Date | Profile | Analysis Date | Analyzer |
|---|---|---|---|---|---|---|
| SB | GRAB | 9 | 11/20/90 | | 1/30/91 | CLK |

X Position :                                   Y Position :

Elevation of Top of Core :
Length of Core :
Depth to Top of Sample :
Depth to Bottom of Sample :

Comments : S-4 BERM CREST

Start Weight : 27.117   Final Weight : 27.073   Deviation : 0.162 %

| PHI | MM | Weight | Percnt | Cumul Percnt | PHI | MM | Weight | Percnt | Cumul Percnt |
|---|---|---|---|---|---|---|---|---|---|
| -2.25 | 4.757 | 0.000 | 0.000 | 0.000 | 1.25 | 0.420 | 0.070 | 0.259 | 0.787 |
| -2.00 | 4.000 | 0.000 | 0.000 | 0.000 | 1.50 | 0.354 | 0.101 | 0.373 | 1.160 |
| -1.75 | 3.364 | 0.000 | 0.000 | 0.000 | 1.75 | 0.297 | 0.423 | 1.562 | 2.722 |
| -1.50 | 2.828 | 0.000 | 0.000 | 0.000 | 2.00 | 0.250 | 2.670 | 9.862 | 12.584 |
| -1.25 | 2.378 | 0.000 | 0.000 | 0.000 | 2.25 | 0.210 | 6.035 | 22.292 | 34.876 |
| -1.00 | 2.000 | 0.000 | 0.000 | 0.000 | 2.50 | 0.177 | 8.642 | 31.921 | 66.797 |
| -0.75 | 1.682 | 0.007 | 0.026 | 0.026 | 2.75 | 0.149 | 5.056 | 18.675 | 85.473 |
| -0.50 | 1.414 | 0.003 | 0.011 | 0.037 | 3.00 | 0.125 | 2.377 | 8.780 | 94.253 |
| -0.25 | 1.189 | 0.012 | 0.044 | 0.081 | 3.25 | 0.105 | 0.950 | 3.509 | 97.762 |
| 0.00 | 1.000 | 0.001 | 0.004 | 0.085 | 3.50 | 0.088 | 0.299 | 1.104 | 98.866 |
| 0.25 | 0.841 | 0.007 | 0.026 | 0.111 | 3.75 | 0.074 | 0.229 | 0.846 | 99.712 |
| 0.50 | 0.707 | 0.026 | 0.096 | 0.207 | 4.00 | 0.063 | 0.066 | 0.244 | 99.956 |
| 0.75 | 0.595 | 0.028 | 0.103 | 0.310 | 4.25 | 0.053 | 0.012 | 0.044 | 100.000 |
| 1.00 | 0.500 | 0.059 | 0.218 | 0.528 | | | | | |

Sample Content by Weight Percent :

| | Gravel | Sand coarse | Sand medium | Sand fine | Silt | Clay |
|---|---|---|---|---|---|---|
| Wentworth Classification | 0.000 | 0.528 | 12.056 | 87.371 | 0.044 | 0.000 |
| Unified Classification | 0.000 | 0.000 | 0.787 | 98.925 | 0.288 | 0.000 |

Standard Statistics :

| | Median | Mean | Dev. | Skew | Kurt |
|---|---|---|---|---|---|
| Method of Moments (PHI) | | 2.38 | 0.40 | -0.22 | 7.62 |
| Folk Graphic Measures (PHI) | 2.37 | 2.38 | 0.36 | 0.07 | -1.06 |
| Grain Size (mm) | 0.19 | 0.19 | | | |

## SARGENT BEACH SEDIMENT ANALYSIS

| Locality | Type | Sample | Date | Profile | Analysis Date | Analyzer |
|---|---|---|---|---|---|---|
| SB | GRAB | 10 | 11/20/90 | | 1/30/91 | CLK |

X Position :　　　　Y Position :

Elevation of Top of Core :
Length of Core :
Depth to Top of Sample :
Depth to Bottom of Sample :

Comments : S-4 MID-TIDE　LOTS OF SMALL SHELL HASH

Start Weight : 26.012　Final Weight : 25.931　Deviation : 0.311 %

| PHI | MM | Weight | Percnt | Cumul Percnt | PHI | MM | Weight | Percnt | Cumul Percnt |
|---|---|---|---|---|---|---|---|---|---|
| -2.25 | 4.757 | 0.000 | 0.000 | 0.000 | 1.25 | 0.420 | 0.370 | 1.427 | 54.766 |
| -2.00 | 4.000 | 6.551 | 25.263 | 25.263 | 1.50 | 0.354 | 0.390 | 1.504 | 56.272 |
| -1.75 | 3.364 | 1.062 | 4.095 | 29.359 | 1.75 | 0.297 | 0.840 | 3.239 | 59.512 |
| -1.50 | 2.828 | 0.581 | 2.241 | 31.599 | 2.00 | 0.250 | 2.060 | 7.944 | 67.456 |
| -1.25 | 2.378 | 0.610 | 2.352 | 33.952 | 2.25 | 0.210 | 2.834 | 10.929 | 78.385 |
| -1.00 | 2.000 | 0.452 | 1.743 | 35.695 | 2.50 | 0.177 | 2.775 | 10.701 | 89.086 |
| -0.75 | 1.682 | 0.379 | 1.462 | 37.156 | 2.75 | 0.149 | 1.574 | 6.070 | 95.156 |
| -0.50 | 1.414 | 0.645 | 2.487 | 39.644 | 3.00 | 0.125 | 0.853 | 3.289 | 98.446 |
| -0.25 | 1.189 | 0.584 | 2.252 | 41.896 | 3.25 | 0.105 | 0.310 | 1.195 | 99.641 |
| 0.00 | 1.000 | 0.496 | 1.913 | 43.809 | 3.50 | 0.088 | 0.065 | 0.251 | 99.892 |
| 0.25 | 0.841 | 0.690 | 2.661 | 46.469 | 3.75 | 0.074 | 0.018 | 0.069 | 99.961 |
| 0.50 | 0.707 | 0.530 | 2.044 | 48.513 | 4.00 | 0.063 | 0.003 | 0.012 | 99.973 |
| 0.75 | 0.595 | 0.550 | 2.121 | 50.634 | 4.25 | 0.053 | 0.007 | 0.027 | 100.000 |
| 1.00 | 0.500 | 0.702 | 2.707 | 53.342 | | | | | |

Sample Content by Weight Percent :

| | Gravel | Sand coarse | Sand medium | Sand fine | Silt | Clay |
|---|---|---|---|---|---|---|
| Wentworth Classification | 35.695 | 17.647 | 14.114 | 32.517 | 0.027 | 0.000 |
| Unified Classification | 0.000 | 35.695 | 19.074 | 45.193 | 0.039 | 0.000 |

Standard Statistics :

| | Median | Mean | Dev. | Skew | Kurt |
|---|---|---|---|---|---|
| Method of Moments (PHI) | | 0.34 | 1.93 | -0.15 | 1.35 |
| Folk Graphic Measures (PHI) | 0.68 | 0.32 | 1.87 | -0.20 | 0.49 |
| Grain Size (mm) | 0.63 | 0.79 | | | |

## SARGENT BEACH SEDIMENT ANALYSIS

| Locality | Type | Sample | Date | Profile | Analysis Date | Analyzer |
|---|---|---|---|---|---|---|
| SB | GRAB | 11 | 11/20/90 | | 1/30/91 | CLK |

X Position :　　　　Y Position :

Elevation of Top of Core :
Length of Core :
Depth to Top of Sample :
Depth to Bottom of Sample :

Comments : S-4 LOW-TIDE LOTS OF SHELL HASH

Start Weight : 18.757　Final Weight : 18.644　Deviation : 0.602 %

| PHI | MM | Weight | Percnt | Cumul Percnt | : | PHI | MM | Weight | Percnt | Cumul Percnt |
|---|---|---|---|---|---|---|---|---|---|---|
| -2.25 | 4.757 | 0.000 | 0.000 | 0.000 | : | 1.25 | 0.420 | 0.315 | 1.690 | 26.936 |
| -2.00 | 4.000 | 0.527 | 2.827 | 2.827 | : | 1.50 | 0.354 | 0.260 | 1.395 | 28.331 |
| -1.75 | 3.364 | 0.096 | 0.515 | 3.342 | : | 1.75 | 0.297 | 0.603 | 3.234 | 31.565 |
| -1.50 | 2.828 | 0.135 | 0.724 | 4.066 | : | 2.00 | 0.250 | 1.386 | 7.434 | 38.999 |
| -1.25 | 2.378 | 0.239 | 1.282 | 5.348 | : | 2.25 | 0.210 | 1.979 | 10.615 | 49.614 |
| -1.00 | 2.000 | 0.283 | 1.518 | 6.865 | : | 2.50 | 0.177 | 2.390 | 12.819 | 62.433 |
| -0.75 | 1.682 | 0.420 | 2.253 | 9.118 | : | 2.75 | 0.149 | 2.129 | 11.419 | 73.852 |
| -0.50 | 1.414 | 0.381 | 2.044 | 11.162 | : | 3.00 | 0.125 | 2.302 | 12.347 | 86.199 |
| -0.25 | 1.189 | 0.421 | 2.258 | 13.420 | : | 3.25 | 0.105 | 1.827 | 9.799 | 95.999 |
| 0.00 | 1.000 | 0.363 | 1.947 | 15.367 | : | 3.50 | 0.088 | 0.565 | 3.030 | 99.029 |
| 0.25 | 0.841 | 0.542 | 2.907 | 18.274 | : | 3.75 | 0.074 | 0.152 | 0.815 | 99.844 |
| 0.50 | 0.707 | 0.419 | 2.247 | 20.521 | : | 4.00 | 0.063 | 0.018 | 0.097 | 99.941 |
| 0.75 | 0.595 | 0.391 | 2.097 | 22.619 | : | 4.25 | 0.053 | 0.011 | 0.059 | 100.000 |
| 1.00 | 0.500 | 0.490 | 2.628 | 25.247 | : | | | | | |

Sample Content by Weight Percent :

| | Gravel | Sand coarse | Sand medium | Sand fine | Silt | Clay |
|---|---|---|---|---|---|---|
| Wentworth Classification | 6.865 | 18.381 | 13.752 | 60.942 | 0.059 | 0.000 |
| Unified Classification | 0.000 | 6.865 | 20.071 | 72.908 | 0.156 | 0.000 |

Standard Statistics :

| | Median | Mean | Dev. | Skew | Kurt |
|---|---|---|---|---|---|
| Method of Moments (PHI) | | 1.75 | 1.43 | -1.16 | 3.36 |
| Folk Graphic Measures (PHI) | 2.26 | 1.76 | 1.41 | -0.55 | 1.04 |
| Grain Size (mm) | 0.21 | 0.30 | | | |

SARGENT BEACH SEDIMENT ANALYSIS

| Locality | Type | Sample | Date | Profile | Analysis Date | Analyzer |
|---|---|---|---|---|---|---|
| SB | GRAB | 12 | 11/20/90 | | 1/30/91 | CLK |

X Position :  Y Position :

Elevation of Top of Core :
Length of Core :
Depth to Top of Sample :
Depth to Bottom of Sample :

Comments : A-1 OVERWASH

Start Weight : 15.200 Final Weight : 15.090 Deviation : 0.724 %

| PHI | MM | Weight | Percnt | Cumul Percnt | : | PHI | MM | Weight | Percnt | Cumul Percnt |
|---|---|---|---|---|---|---|---|---|---|---|
| -2.25 | 4.757 | 0.000 | 0.000 | 0.000 | : | 1.25 | 0.420 | 0.079 | 0.524 | 5.010 |
| -2.00 | 4.000 | 0.000 | 0.000 | 0.000 | : | 1.50 | 0.354 | 0.086 | 0.570 | 5.580 |
| -1.75 | 3.364 | 0.000 | 0.000 | 0.000 | : | 1.75 | 0.297 | 0.323 | 2.140 | 7.720 |
| -1.50 | 2.828 | 0.033 | 0.219 | 0.219 | : | 2.00 | 0.250 | 1.408 | 9.331 | 17.051 |
| -1.25 | 2.378 | 0.000 | 0.000 | 0.219 | : | 2.25 | 0.210 | 3.249 | 21.531 | 38.582 |
| -1.00 | 2.000 | 0.023 | 0.152 | 0.371 | : | 2.50 | 0.177 | 4.390 | 29.092 | 67.674 |
| -0.75 | 1.682 | 0.035 | 0.232 | 0.603 | : | 2.75 | 0.149 | 2.812 | 18.635 | 86.309 |
| -0.50 | 1.414 | 0.014 | 0.093 | 0.696 | : | 3.00 | 0.125 | 1.384 | 9.172 | 95.480 |
| -0.25 | 1.189 | 0.058 | 0.384 | 1.080 | : | 3.25 | 0.105 | 0.486 | 3.221 | 98.701 |
| 0.00 | 1.000 | 0.074 | 0.490 | 1.571 | : | 3.50 | 0.088 | 0.117 | 0.775 | 99.476 |
| 0.25 | 0.841 | 0.095 | 0.630 | 2.200 | : | 3.75 | 0.074 | 0.050 | 0.331 | 99.808 |
| 0.50 | 0.707 | 0.103 | 0.683 | 2.883 | : | 4.00 | 0.063 | 0.014 | 0.093 | 99.901 |
| 0.75 | 0.595 | 0.098 | 0.649 | 3.532 | : | 4.25 | 0.053 | 0.015 | 0.099 | 100.000 |
| 1.00 | 0.500 | 0.144 | 0.954 | 4.486 | : | | | | | |

Sample Content by Weight Percent :

| | Gravel | Sand coarse | Sand medium | Sand fine | Silt | Clay |
|---|---|---|---|---|---|---|
| Wentworth Classification | 0.371 | 4.115 | 12.565 | 82.850 | 0.099 | 0.000 |
| Unified Classification | 0.000 | 0.371 | 4.639 | 94.798 | 0.192 | 0.000 |

Standard Statistics :

| | Median | Mean | Dev. | Skew | Kurt |
|---|---|---|---|---|---|
| Method of Moments (PHI) | | 2.28 | 0.61 | -2.39 | 12.81 |
| Folk Graphic Measures (PHI) | 2.35 | 2.35 | 0.45 | -0.14 | 1.41 |
| Grain Size (mm) | 0.20 | 0.21 | | | |

## SARGENT BEACH SEDIMENT ANALYSIS

| Locality | Type | Sample | Date | Profile | Analysis Date | Analyzer |
|---|---|---|---|---|---|---|
| SB | GRAB | 13 | 11/20/90 | | 1/30/91 | CLK |

X Position :　　　　Y Position :

Elevation of Top of Core :
Length of Core :
Depth to Top of Sample :
Depth to Bottom of Sample :

Comments : A-1 BERM CREST

Start Weight : 25.489　Final Weight : 25.373　Deviation : 0.455 %

| PHI | MM | Weight | Percnt | Cumul Percnt | : | PHI | MM | Weight | Percnt | Cumul Percnt |
|---|---|---|---|---|---|---|---|---|---|---|
| -2.25 | 4.757 | 0.000 | 0.000 | 0.000 | : | 1.25 | 0.420 | 0.076 | 0.300 | 1.549 |
| -2.00 | 4.000 | 0.000 | 0.000 | 0.000 | : | 1.50 | 0.354 | 0.073 | 0.288 | 1.837 |
| -1.75 | 3.364 | 0.022 | 0.087 | 0.087 | : | 1.75 | 0.297 | 0.326 | 1.285 | 3.121 |
| -1.50 | 2.828 | 0.000 | 0.000 | 0.087 | : | 2.00 | 0.250 | 2.410 | 9.498 | 12.620 |
| -1.25 | 2.378 | 0.000 | 0.000 | 0.087 | : | 2.25 | 0.210 | 6.605 | 26.032 | 38.651 |
| -1.00 | 2.000 | 0.033 | 0.130 | 0.217 | : | 2.50 | 0.177 | 7.776 | 30.647 | 69.298 |
| -0.75 | 1.682 | 0.019 | 0.075 | 0.292 | : | 2.75 | 0.149 | 3.882 | 15.300 | 84.598 |
| -0.50 | 1.414 | 0.032 | 0.126 | 0.418 | : | 3.00 | 0.125 | 1.811 | 7.138 | 91.735 |
| -0.25 | 1.189 | 0.007 | 0.028 | 0.445 | : | 3.25 | 0.105 | 1.091 | 4.300 | 96.035 |
| 0.00 | 1.000 | 0.016 | 0.063 | 0.508 | : | 3.50 | 0.088 | 0.559 | 2.203 | 98.238 |
| 0.25 | 0.841 | 0.037 | 0.146 | 0.654 | : | 3.75 | 0.074 | 0.361 | 1.423 | 99.661 |
| 0.50 | 0.707 | 0.029 | 0.114 | 0.769 | : | 4.00 | 0.063 | 0.074 | 0.292 | 99.953 |
| 0.75 | 0.595 | 0.050 | 0.197 | 0.966 | : | 4.25 | 0.053 | 0.012 | 0.047 | 100.000 |
| 1.00 | 0.500 | 0.072 | 0.284 | 1.249 | : | | | | | |

Sample Content by Weight Percent :

| | Gravel | Sand coarse | Sand medium | Sand fine | Silt | Clay |
|---|---|---|---|---|---|---|
| Wentworth Classification | 0.217 | 1.033 | 11.370 | 87.333 | 0.047 | 0.000 |
| Unified Classification | 0.000 | 0.217 | 1.332 | 98.112 | 0.339 | 0.000 |

Standard Statistics :

| | Median | Mean | Dev. | Skew | Kurt |
|---|---|---|---|---|---|
| Method of Moments (PHI) | | 2.37 | 0.49 | -1.50 | 15.70 |
| Folk Graphic Measures (PHI) | 2.34 | 2.37 | 0.39 | 0.17 | 1.20 |
| Grain Size (mm) | 0.20 | 0.19 | | | |

## SARGENT BEACH SEDIMENT ANALYSIS

| Locality | Type | Sample | Date | Profile | Analysis Date | Analyzer |
|---|---|---|---|---|---|---|
| SB | GRAB | 14 | 11/20/90 | | 1/30/91 | CLK |

X Position :  Y Position :

Elevation of Top of Core :
Length of Core :
Depth to Top of Sample :
Depth to Bottom of Sample :

Comments : A-1 MID-TIDE

Start Weight : 25.065 Final Weight : 24.977 Deviation : 0.351 %

| PHI | MM | Weight | Percnt | Cumul Percnt | : | PHI | MM | Weight | Percnt | Cumul Percnt |
|---|---|---|---|---|---|---|---|---|---|---|
| -2.25 | 4.757 | 0.000 | 0.000 | 0.000 | : | 1.25 | 0.420 | 0.117 | 0.468 | 4.472 |
| -2.00 | 4.000 | 0.081 | 0.324 | 0.324 | : | 1.50 | 0.354 | 0.141 | 0.565 | 5.037 |
| -1.75 | 3.364 | 0.128 | 0.512 | 0.837 | : | 1.75 | 0.297 | 0.481 | 1.926 | 6.962 |
| -1.50 | 2.828 | 0.041 | 0.164 | 1.001 | : | 2.00 | 0.250 | 2.275 | 9.108 | 16.071 |
| -1.25 | 2.378 | 0.015 | 0.060 | 1.061 | : | 2.25 | 0.210 | 4.496 | 18.001 | 34.071 |
| -1.00 | 2.000 | 0.054 | 0.216 | 1.277 | : | 2.50 | 0.177 | 6.521 | 26.108 | 60.179 |
| -0.75 | 1.682 | 0.044 | 0.176 | 1.453 | : | 2.75 | 0.149 | 5.235 | 20.959 | 81.139 |
| -0.50 | 1.414 | 0.078 | 0.312 | 1.766 | : | 3.00 | 0.125 | 3.094 | 12.387 | 93.526 |
| -0.25 | 1.189 | 0.101 | 0.404 | 2.170 | : | 3.25 | 0.105 | 1.234 | 4.941 | 98.467 |
| 0.00 | 1.000 | 0.060 | 0.240 | 2.410 | : | 3.50 | 0.088 | 0.223 | 0.893 | 99.359 |
| 0.25 | 0.841 | 0.081 | 0.324 | 2.735 | : | 3.75 | 0.074 | 0.117 | 0.468 | 99.828 |
| 0.50 | 0.707 | 0.088 | 0.352 | 3.087 | : | 4.00 | 0.063 | 0.035 | 0.140 | 99.968 |
| 0.75 | 0.595 | 0.084 | 0.336 | 3.423 | : | 4.25 | 0.053 | 0.008 | 0.032 | 100.000 |
| 1.00 | 0.500 | 0.145 | 0.581 | 4.004 | : | | | | | |

Sample Content by Weight Percent :

| | Gravel | Sand coarse | Sand medium | Sand fine | Silt | Clay |
|---|---|---|---|---|---|---|
| Wentworth Classification | 1.277 | 2.727 | 12.067 | 83.897 | 0.032 | 0.000 |
| Unified Classification | 0.000 | 1.277 | 3.195 | 95.356 | 0.172 | 0.000 |

Standard Statistics :

| | Median | Mean | Dev. | Skew | Kurt |
|---|---|---|---|---|---|
| Method of Moments (PHI) | | 2.31 | 0.72 | -3.18 | 17.65 |
| Folk Graphic Measures (PHI) | 2.40 | 2.40 | 0.44 | -0.05 | 1.18 |
| Grain Size (mm) | 0.19 | 0.20 | | | |

## SARGENT BEACH SEDIMENT ANALYSIS

| Locality | Type | Sample | Date | Profile | Analysis Date | Analyzer |
|---|---|---|---|---|---|---|
| SB | GRAB | 15 | 11/20/90 | | 1/30/91 | CLK |

X Position :                Y Position :

Elevation of Top of Core :
Length of Core :
Depth to Top of Sample :
Depth to Bottom of Sample :

Comments : E.MATAGORDA BAY INLET N.SIDE MID-TIDE SOME SHELL

Start Weight : 30.298   Final Weight : 30.048   Deviation : 0.825 %

| PHI | MM | Weight | Percnt | Cumul Percnt | : | PHI | MM | Weight | Percnt | Cumul Percnt |
|---|---|---|---|---|---|---|---|---|---|---|
| -2.25 | 4.757 | 0.000 | 0.000 | 0.000 | : | 1.25 | 0.420 | 0.848 | 2.822 | 26.311 |
| -2.00 | 4.000 | 2.283 | 7.598 | 7.598 | : | 1.50 | 0.354 | 0.918 | 3.055 | 29.366 |
| -1.75 | 3.364 | 0.074 | 0.246 | 7.844 | : | 1.75 | 0.297 | 1.708 | 5.684 | 35.051 |
| -1.50 | 2.828 | 0.272 | 0.905 | 8.749 | : | 2.00 | 0.250 | 3.202 | 10.656 | 45.707 |
| -1.25 | 2.378 | 0.316 | 1.052 | 9.801 | : | 2.25 | 0.210 | 4.052 | 13.485 | 59.192 |
| -1.00 | 2.000 | 0.178 | 0.592 | 10.393 | : | 2.50 | 0.177 | 5.039 | 16.770 | 75.962 |
| -0.75 | 1.682 | 0.149 | 0.496 | 10.889 | : | 2.75 | 0.149 | 3.903 | 12.989 | 88.951 |
| -0.50 | 1.414 | 0.244 | 0.812 | 11.701 | : | 3.00 | 0.125 | 2.431 | 8.090 | 97.041 |
| -0.25 | 1.189 | 0.271 | 0.902 | 12.603 | : | 3.25 | 0.105 | 0.781 | 2.599 | 99.641 |
| 0.00 | 1.000 | 0.252 | 0.839 | 13.442 | : | 3.50 | 0.088 | 0.084 | 0.280 | 99.920 |
| 0.25 | 0.841 | 0.524 | 1.744 | 15.186 | : | 3.75 | 0.074 | 0.016 | 0.053 | 99.973 |
| 0.50 | 0.707 | 0.419 | 1.394 | 16.580 | : | 4.00 | 0.063 | 0.004 | 0.013 | 99.987 |
| 0.75 | 0.595 | 0.750 | 2.496 | 19.076 | : | 4.25 | 0.053 | 0.004 | 0.013 | 100.000 |
| 1.00 | 0.500 | 1.326 | 4.413 | 23.489 | : | | | | | |

Sample Content by Weight Percent :

| | Gravel | Sand coarse | Sand medium | Sand fine | Silt | Clay |
|---|---|---|---|---|---|---|
| Wentworth Classification | 10.393 | 13.096 | 22.216 | 54.280 | 0.013 | 0.000 |
| Unified Classification | 0.000 | 10.393 | 15.918 | 73.662 | 0.027 | 0.000 |

Standard Statistics :

| | Median | Mean | Dev. | Skew | Kurt |
|---|---|---|---|---|---|
| Method of Moments (PHI) | | 1.56 | 1.43 | -1.50 | 4.26 |
| Folk Graphic Measures (PHI) | 2.08 | 1.71 | 1.33 | -0.57 | 1.52 |
| Grain Size (mm) | 0.24 | 0.34 | | | |

SARGENT BEACH SEDIMENT ANALYSIS

| Locality | Type | Sample | Date | Profile | Analysis Date | Analyz |
|---|---|---|---|---|---|---|
| SB | CORE | HA-S2-3 | | | | CRL |

X Position :                    Y Position :

Elevation of Top of Core :
Length of Core :
Depth to Top of Sample : -85 cm
Depth to Bottom of Sample :

Comments :HA-S2-3 (COMPOSITE OF 3 REPLICATES)

Start Weight :    Final Weight : 6.723    Deviation : %

| PHI | MM | Weight | Percnt | Cumul Percnt | PHI | MM | Weight | Percnt | Cumul Percnt |
|---|---|---|---|---|---|---|---|---|---|
| 3.50 | 0.088 | 0.000 | 0.000 | 0.000 | 6.00 | 0.016 | 0.167 | 2.484 | 57.861 |
| 4.00 | 0.063 | 2.640 | 39.268 | 39.268 | 7.00 | 0.008 | 0.333 | 4.953 | 62.814 |
| 4.50 | 0.044 | 0.500 | 7.437 | 46.705 | 8.00 | 0.004 | 0.333 | 4.953 | 67.767 |
| 5.00 | 0.031 | 0.250 | 3.719 | 50.424 | 9.00 | 0.002 | 0.167 | 2.484 | 70.251 |
| 5.50 | 0.022 | 0.333 | 4.953 | 55.377 | 9.50 | 0.001 | 2.000 | 29.749 | 100.000 |

Sample Content by Weight Percent :

| | Gravel | Sand coarse | Sand medium | Sand fine | Silt | Clay |
|---|---|---|---|---|---|---|
| Wentworth Classification | 0.000 | 0.000 | 0.000 | 39.268 | 28.499 | 32.233 |
| Unified Classification | 0.000 | 0.000 | 0.000 | 0.000 | 67.767 | 32.233 |

Standard Statistics :

| | Median | Mean | Dev. | Skew | Kurt |
|---|---|---|---|---|---|
| Method of Moments (PHI) | | 6.02 | 2.39 | 0.39 | 1.37 |
| Folk Graphic Measures (PHI) | 4.94 | 5.96 | 2.27 | 0.54 | 0.46 |
| Grain Size (mm) | 0.03 | 0.02 | | | |

*** Silt & clay exceeds 5.0%. Fine grain analysis may be required. ***

SARGENT BEACH, TX

| Locality | Type | Sample | Date | Profile | Analysis Date | Analyz |
|---|---|---|---|---|---|---|
| | CoAF | HA-S4-3 | | | | CRL |

X Position :  Y Position :

Elevation of Top of Core :
Length of Core :
Depth to Top of Sample : -75cm
Depth to Bottom of Sample :

Comments : MID-LOW TIDE (COMPOSITE OF 3 REPLICATES)

Start Weight :  Final Weight : 4.541  Deviation : %

| PHI | MM | Weight | Percnt | Cumul Percnt | PHI | MM | Weight | Percnt | Cumul Percnt |
|---|---|---|---|---|---|---|---|---|---|
| 3.50 | 0.088 | 0.000 | 0.000 | 0.000 | 6.00 | 0.016 | 0.167 | 3.678 | 28.055 |
| 4.00 | 0.063 | 0.257 | 5.660 | 5.660 | 7.00 | 0.008 | 0.217 | 4.779 | 32.834 |
| 4.50 | 0.044 | 0.300 | 6.606 | 12.266 | 8.00 | 0.004 | 0.250 | 5.505 | 38.340 |
| 5.00 | 0.031 | 0.417 | 9.183 | 21.449 | 9.00 | 0.002 | 0.317 | 6.981 | 45.320 |
| 5.50 | 0.022 | 0.133 | 2.929 | 24.378 | 10.00 | 0.001 | 2.483 | 54.680 | 100.000 |

Sample Content by Weight Percent :

| | Gravel | Sand coarse | Sand medium | Sand fine | Silt | Clay |
|---|---|---|---|---|---|---|
| Wentworth Classification | 0.000 | 0.000 | 0.000 | 5.660 | 32.680 | 61.660 |
| Unified Classification | 0.000 | 0.000 | 0.000 | 0.000 | 38.340 | 61.660 |

Standard Statistics :

| | Median | Mean | Dev. | Skew | Kurt |
|---|---|---|---|---|---|
| Method of Moments (PHI) | | 7.81 | 2.16 | -0.76 | 1.86 |
| Folk Graphic Measures (PHI) | 9.09 | 7.83 | 2.16 | -0.74 | 0.62 |
| Grain Size (mm) | 0.00 | 0.00 | | | |

*** Silt & clay exceeds 5.0%. Fine grain analysis may be required. ***

## SARGENT BEACH SEDIMENT ANALYSIS

| Locality | Type | Sample | Date | Profile | Analysis Date | Analyzer |
|---|---|---|---|---|---|---|
| SB | | S-2COMP2 | | | | |

X Position : .                Y Position :

Elevation of Top of Core :
Length of Core :
Depth to Top of Sample :
Depth to Bottom of Sample :

Comments : S-2 COMPOSITE (BERM, MID-TIDE, LOW-TIDE)

Start Weight :                . Final Weight : 26.881 . Deviation : %

| PHI | MM | Weight | Percent | Cumul Percent | PHI | MM | Weight | Percent | Cumul Percent |
|---|---|---|---|---|---|---|---|---|---|
| -2.25 | 4.757 | 0.000 | 0.000 | 0.000 | 1.25 | 0.420 | 0.190 | 0.707 | 41.483 |
| -2.00 | 4.000 | 1.667 | 6.201 | 6.201 | 1.50 | 0.354 | 0.162 | 0.603 | 42.085 |
| -1.75 | 3.364 | 0.665 | 2.474 | 8.675 | 1.75 | 0.297 | 0.326 | 1.213 | 43.298 |
| -1.50 | 2.828 | 0.762 | 2.835 | 11.510 | 2.00 | 0.250 | 1.013 | 3.768 | 47.067 |
| -1.25 | 2.378 | 0.771 | 2.868 | 14.378 | 2.25 | 0.210 | 2.318 | 8.623 | 55.690 |
| -1.00 | 2.000 | 0.919 | 3.419 | 17.797 | 2.50 | 0.177 | 3.767 | 14.014 | 69.704 |
| -0.75 | 1.682 | 0.982 | 3.653 | 21.450 | 2.75 | 0.149 | 3.515 | 13.076 | 82.780 |
| -0.50 | 1.414 | 1.285 | 4.780 | 26.230 | 3.00 | 0.125 | 2.795 | 10.398 | 93.177 |
| -0.25 | 1.189 | 1.109 | 4.126 | 30.356 | 3.25 | 0.105 | 1.489 | 5.539 | 98.717 |
| 0.00 | 1.000 | 0.752 | 2.798 | 33.154 | 3.50 | 0.088 | 0.250 | 0.930 | 99.647 |
| 0.25 | 0.841 | 0.784 | 2.917 | 36.070 | 3.75 | 0.074 | 0.072 | 0.268 | 99.914 |
| 0.50 | 0.707 | 0.487 | 1.812 | 37.882 | 4.00 | 0.063 | 0.014 | 0.052 | 99.967 |
| 0.75 | 0.595 | 0.373 | 1.388 | 39.269 | 4.25 | 0.053 | 0.009 | 0.033 | 100.000 |
| 1.00 | 0.500 | 0.405 | 1.507 | 40.776 | | | | | |

Sample Content by Weight Percent :

| | Gravel | Sand coarse | Sand medium | Sand fine | Silt | Clay |
|---|---|---|---|---|---|---|
| Wentworth Classification | 17.797 | 22.979 | 6.291 | 52.900 | 0.033 | 0.000 |
| Unified Classification | 0.000 | 17.797 | 23.686 | 58.432 | 0.066 | 0.000 |

Standard Statistics :

| | Median | Mean | Dev. | Skew | Kurt |
|---|---|---|---|---|---|
| Method of Moments (PHI) | | 1.13 | 1.78 | -0.55 | 1.74 |
| Folk Graphic Measures (PHI) | 2.09 | 1.24 | 1.76 | -0.63 | 0.66 |
| Grain Size (mm) | 0.24 | 0.46 | | | |

## SARGENT BEACH SEDIMENT ANALYSIS

| Locality | Type | Sample | Date | Profile | Analysis Date | Analyzer |
|---|---|---|---|---|---|---|
| SB | | S-4COMP2 | | | | DKS |

X Position :  Y Position :

Elevation of Top of Core :
Length of Core :
Depth to Top of Sample :
Depth to Bottom of Sample :

Comments : S-4 COMPOSITE (BERM, MID-TIDE, LOW-TIDE)

Start Weight :  Final Weight : 23.884  Deviation : %

| PHI | MM | Weight | Percnt | Cumul Percnt | PHI | MM | Weight | Percnt | Cumul Percnt |
|---|---|---|---|---|---|---|---|---|---|
| -2.25 | 4.757 | 0.000 | 0.000 | 0.000 | 1.25 | 0.420 | 0.252 | 1.055 | 27.131 |
| -2.00 | 4.000 | 2.359 | 9.877 | 9.877 | 1.50 | 0.354 | 0.250 | 1.047 | 28.178 |
| -1.75 | 3.364 | 0.386 | 1.616 | 11.493 | 1.75 | 0.297 | 0.622 | 2.604 | 30.782 |
| -1.50 | 2.828 | 0.239 | 1.001 | 12.494 | 2.00 | 0.250 | 2.039 | 8.537 | 39.319 |
| -1.25 | 2.378 | 0.283 | 1.185 | 13.679 | 2.25 | 0.210 | 3.616 | 15.140 | 54.459 |
| -1.00 | 2.000 | 0.245 | 1.026 | 14.704 | 2.50 | 0.177 | 4.602 | 19.268 | 73.727 |
| -0.75 | 1.682 | 0.269 | 1.126 | 15.831 | 2.75 | 0.149 | 2.920 | 12.226 | 85.953 |
| -0.50 | 1.414 | 0.343 | 1.436 | 17.267 | 3.00 | 0.125 | 1.844 | 7.721 | 93.674 |
| -0.25 | 1.189 | 0.339 | 1.419 | 18.686 | 3.25 | 0.105 | 1.029 | 4.308 | 97.982 |
| 0.00 | 1.000 | 0.287 | 1.202 | 19.888 | 3.50 | 0.088 | 0.310 | 1.298 | 99.280 |
| 0.25 | 0.841 | 0.413 | 1.729 | 21.617 | 3.75 | 0.074 | 0.133 | 0.557 | 99.837 |
| 0.50 | 0.707 | 0.325 | 1.361 | 22.978 | 4.00 | 0.063 | 0.029 | 0.121 | 99.958 |
| 0.75 | 0.595 | 0.323 | 1.352 | 24.330 | 4.25 | 0.053 | 0.010 | 0.042 | 100.000 |
| 1.00 | 0.500 | 0.417 | 1.746 | 26.076 | | | | | |

Sample Content by Weight Percent :

| | Gravel | Sand coarse | Sand medium | Sand fine | Silt | Clay |
|---|---|---|---|---|---|---|
| Wentworth Classification | 14.704 | 11.372 | 13.243 | 60.639 | 0.042 | 0.000 |
| Unified Classification | 0.000 | 14.704 | 12.427 | 72.706 | 0.163 | 0.000 |

Standard Statistics :

| | Median | Mean | Dev. | Skew | Kurt |
|---|---|---|---|---|---|
| Method of Moments (PHI) | | 1.48 | 1.66 | -1.22 | 3.09 |
| Folk Graphic Measures (PHI) | 2.18 | 1.39 | 1.65 | -0.67 | 1.27 |
| Grain Size (mm) | 0.22 | 0.36 | | | |

**SARGENT BEACH SEDIMENT ANALYSIS**

| Locality | Type | Sample | Date | Profile | Analysis Date | Analyzer |
|---|---|---|---|---|---|---|
| SB | | A-1COMP2 | | | | DKS |

X Position :                Y Position :

Elevation of Top of Core :
Length of Core :
Depth to Top of Sample :
Depth to Bottom of Sample :

Comments : A-1 COMPOSITE (BERM, MID-TIDE (NO LT))

Start Weight :        Final Weight : 25.167    Deviation :        %

| PHI | MM | Weight | Percent | Cumul Percnt | : | PHI | MM | Weight | Percent | Cumul Percnt |
|---|---|---|---|---|---|---|---|---|---|---|
| -2.25 | 4.757 | 0.000 | 0.000 | 0.000 | : | 1.25 | 0.420 | 0.096 | 0.381 | 2.984 |
| -2.00 | 4.000 | 0.040 | 0.159 | 0.159 | : | 1.50 | 0.354 | 0.107 | 0.425 | 3.409 |
| -1.75 | 3.364 | 0.075 | 0.298 | 0.457 | : | 1.75 | 0.297 | 0.403 | 1.601 | 5.011 |
| -1.50 | 2.828 | 0.020 | 0.079 | 0.536 | : | 2.00 | 0.250 | 2.342 | 9.306 | 14.316 |
| -1.25 | 2.378 | 0.007 | 0.028 | 0.564 | : | 2.25 | 0.210 | 5.550 | 22.052 | 36.369 |
| -1.00 | 2.000 | 0.043 | 0.171 | 0.735 | : | 2.50 | 0.177 | 7.148 | 28.402 | 64.771 |
| -0.75 | 1.682 | 0.031 | 0.123 | 0.858 | : | 2.75 | 0.149 | 4.558 | 18.111 | 82.882 |
| -0.50 | 1.414 | 0.055 | 0.219 | 1.077 | : | 3.00 | 0.125 | 2.452 | 9.743 | 92.625 |
| -0.25 | 1.189 | 0.054 | 0.215 | 1.291 | : | 3.25 | 0.105 | 1.162 | 4.617 | 97.242 |
| 0.00 | 1.000 | 0.038 | 0.151 | 1.442 | : | 3.50 | 0.088 | 0.391 | 1.554 | 98.796 |
| 0.25 | 0.841 | 0.059 | 0.234 | 1.677 | : | 3.75 | 0.074 | 0.239 | 0.950 | 99.746 |
| 0.50 | 0.707 | 0.058 | 0.230 | 1.907 | : | 4.00 | 0.063 | 0.054 | 0.215 | 99.960 |
| 0.75 | 0.595 | 0.067 | 0.266 | 2.173 | : | 4.25 | 0.053 | 0.010 | 0.040 | 100.000 |
| 1.00 | 0.500 | 0.108 | 0.429 | 2.603 | : | | | | | |

Sample Content by Weight Percent :

| | Gravel | Sand coarse | Sand medium | Sand fine | Silt | Clay |
|---|---|---|---|---|---|---|
| Wentworth Classification | 0.735 | 1.868 | 11.714 | 85.644 | 0.040 | 0.000 |
| Unified Classification | 0.000 | 0.735 | 2.249 | 96.762 | 0.254 | 0.000 |

Standard Statistics :

| | Median | Mean | Dev. | Skew | Kurt |
|---|---|---|---|---|---|
| Method of Moments (PHI) | | 2.34 | 0.91 | -2.94 | 19.91 |
| Folk Graphic Measures (PHI) | 2.37 | 2.39 | 0.40 | 0.09 | 1.09 |
| Grain Size (mm) | 0.19 | 0.20 | | | |

## SARGENT BEACH SEDIMENT ANALYSIS

| Locality | Type | Sample | Date | Profile | Analysis Date | Analyz |
|---|---|---|---|---|---|---|
| SB | GRAB | A-1<br>Comp 3 | 11/20/90 | | 1/30/91 | CLK/CRL |

X Position :                Y Position :

Elevation of Top of Core :
Length of Core :
Depth to Top of Sample :
Depth to Bottom of Sample :

Comments : A-1 COMPOSITE OF BERM, MID-TIDE, & LOW TIDE

Start Weight :        Final Weight : 30.025    Deviation : %

| PHI | MM | Weight | Percnt | Cumul Percnt | PHI | MM | Weight | Percnt | Cumul Percnt |
|---|---|---|---|---|---|---|---|---|---|
| -2.25 | 4.757 | 0.000 | 0.000 | 0.000 | 3.75 | 0.074 | 0.699 | 2.328 | 63.247 |
| -2.00 | 4.000 | 0.069 | 0.230 | 0.230 | 4.00 | 0.063 | 0.439 | 1.462 | 64.709 |
| -1.75 | 3.364 | 0.055 | 0.183 | 0.413 | 4.25 | 0.053 | 0.253 | 0.843 | 65.552 |
| -1.50 | 2.828 | 0.015 | 0.050 | 0.463 | 4.50 | 0.044 | 0.738 | 2.458 | 68.010 |
| -1.25 | 2.378 | 0.010 | 0.033 | 0.496 | 4.75 | 0.037 | 1.477 | 4.919 | 72.929 |
| -1.00 | 2.000 | 0.040 | 0.133 | 0.629 | 5.00 | 0.031 | 1.477 | 4.919 | 77.848 |
| -0.75 | 1.682 | 0.025 | 0.083 | 0.713 | 5.25 | 0.026 | 0.369 | 1.229 | 79.077 |
| -0.50 | 1.414 | 0.046 | 0.153 | 0.866 | 5.50 | 0.022 | 0.369 | 1.229 | 80.306 |
| -0.25 | 1.189 | 0.037 | 0.123 | 0.989 | 5.75 | 0.019 | 0.000 | 0.000 | 80.306 |
| 0.00 | 1.000 | 0.028 | 0.093 | 1.082 | 6.00 | 0.016 | 0.000 | 0.000 | 80.306 |
| 0.25 | 0.841 | 0.040 | 0.133 | 1.216 | 6.25 | 0.013 | 0.185 | 0.616 | 80.923 |
| 0.50 | 0.707 | 0.041 | 0.137 | 1.352 | 6.50 | 0.011 | 0.185 | 0.616 | 81.539 |
| 0.75 | 0.595 | 0.046 | 0.153 | 1.505 | 6.75 | 0.009 | 0.185 | 0.616 | 82.155 |
| 1.00 | 0.500 | 0.075 | 0.250 | 1.755 | 7.00 | 0.008 | 0.185 | 0.616 | 82.771 |
| 1.25 | 0.420 | 0.067 | 0.223 | 1.978 | 7.25 | 0.007 | 0.000 | 0.000 | 82.771 |
| 1.50 | 0.354 | 0.074 | 0.246 | 2.225 | 7.50 | 0.006 | 0.000 | 0.000 | 82.771 |
| 1.75 | 0.297 | 0.276 | 0.919 | 3.144 | 7.75 | 0.005 | 0.000 | 0.000 | 82.771 |
| 2.00 | 0.250 | 1.590 | 5.296 | 8.440 | 8.00 | 0.004 | 0.000 | 0.000 | 82.771 |
| 2.25 | 0.210 | 3.764 | 12.536 | 20.976 | 8.25 | 0.003 | 0.185 | 0.616 | 83.387 |
| 2.50 | 0.177 | 4.902 | 16.326 | 37.302 | 8.50 | 0.003 | 0.185 | 0.616 | 84.003 |
| 2.75 | 0.149 | 3.260 | 10.858 | 48.160 | 8.75 | 0.002 | 0.185 | 0.616 | 84.619 |
| 3.00 | 0.125 | 1.936 | 6.448 | 54.608 | 9.00 | 0.002 | 0.185 | 0.616 | 85.236 |
| 3.25 | 0.105 | 1.316 | 4.383 | 58.991 | 9.25 | 0.002 | 4.433 | 14.764 | 100.000 |
| 3.50 | 0.088 | 0.579 | 1.928 | 60.919 | | | | | |

Sample Content by Weight Percent :

| | Gravel | Sand coarse | Sand medium | Sand fine | Silt | Clay |
|---|---|---|---|---|---|---|
| Wentworth Classification | 0.629 | 1.126 | 6.684 | 56.270 | 18.062 | 17.229 |
| Unified Classification | 0.000 | 0.629 | 1.349 | 61.269 | 19.524 | 17.229 |

Standard Statistics :

| | Median | Mean | Dev. | Skew | Kurt |
|---|---|---|---|---|---|
| Method of Moments (PHI) | | 4.03 | 2.56 | 1.04 | 2.94 |
| Folk Graphic Measures (PHI) | 2.82 | 4.49 | 2.70 | 0.76 | 1.18 |
| Grain Size (mm) | 0.14 | 0.06 | | | |

**SARGENT BEACH SEDIMENT ANALYSIS**

| Locality | Type | Sample | Date | Profile | Analysis Date | Analyzer |
|---|---|---|---|---|---|---|
| SB | | CLCOMP | | | | DKS |

X Position :                                  Y Position :

Elevation of Top of Core :
Length of Core :
Depth to Top of Sample :
Depth to Bottom of Sample :

Comments : CEDARLAKES COMPOSITE (CONTAINS BERM, MT, LT)

Start Weight :          Final Weight : 18.263     Deviation : %

| PHI | MM | Weight | Percnt | Cumul Percnt | PHI | MM | Weight | Percnt | Cumul Percnt |
|---|---|---|---|---|---|---|---|---|---|
| -2.25 | 4.757 | 0.000 | 0.000 | 0.000 | 1.25 | 0.420 | 0.115 | 0.630 | 8.887 |
| -2.00 | 4.000 | 0.643 | 3.521 | 3.521 | 1.50 | 0.354 | 0.134 | 0.734 | 9.621 |
| -1.75 | 3.364 | 0.065 | 0.356 | 3.877 | 1.75 | 0.297 | 0.382 | 2.092 | 11.712 |
| -1.50 | 2.828 | 0.095 | 0.520 | 4.397 | 2.00 | 0.250 | 1.299 | 7.113 | 18.825 |
| -1.25 | 2.378 | 0.103 | 0.564 | 4.961 | 2.25 | 0.210 | 2.326 | 12.736 | 31.561 |
| -1.00 | 2.000 | 0.053 | 0.290 | 5.251 | 2.50 | 0.177 | 2.779 | 15.217 | 46.778 |
| -0.75 | 1.682 | 0.051 | 0.279 | 5.530 | 2.75 | 0.149 | 2.346 | 12.846 | 59.623 |
| -0.50 | 1.414 | 0.058 | 0.318 | 5.848 | 3.00 | 0.125 | 2.932 | 16.054 | 75.678 |
| -0.25 | 1.189 | 0.048 | 0.263 | 6.111 | 3.25 | 0.105 | 3.472 | 19.011 | 94.689 |
| 0.00 | 1.000 | 0.047 | 0.257 | 6.368 | 3.50 | 0.088 | 0.788 | 4.315 | 99.003 |
| 0.25 | 0.841 | 0.074 | 0.405 | 6.773 | 3.75 | 0.074 | 0.155 | 0.849 | 99.852 |
| 0.50 | 0.707 | 0.064 | 0.350 | 7.124 | 4.00 | 0.063 | 0.018 | 0.099 | 99.951 |
| 0.75 | 0.595 | 0.077 | 0.422 | 7.545 | 4.25 | 0.053 | 0.009 | 0.049 | 100.000 |
| 1.00 | 0.500 | 0.130 | 0.712 | 8.257 | | | | | |

Sample Content by Weight Percent :

| | Gravel | Sand coarse | Sand medium | Sand fine | Silt | Clay |
|---|---|---|---|---|---|---|
| Wentworth Classification | 5.251 | 3.006 | 10.568 | 81.126 | 0.049 | 0.000 |
| Unified Classification | 0.000 | 5.251 | 3.636 | 90.965 | 0.148 | 0.000 |

Standard Statistics :

| | Median | Mean | Dev. | Skew | Kurt |
|---|---|---|---|---|---|
| Method of Moments (PHI) | | 2.30 | 1.18 | -2.57 | 9.40 |
| Folk Graphic Measures (PHI) | 2.56 | 2.52 | 0.98 | -0.39 | +2.1[illegible] |
| Grain Size (mm) | 0.17 | 0.20 | | | |

## SARGENT BEACH, TX

| Locality | Type | Sample | Date | Profile | Analysis Date | Analy |
|---|---|---|---|---|---|---|
| LOW TIDE | SURFACE | A1S&C | | | | CRL |

X Position :　　　　Y Position :

Elevation of Top of Core :
Length of Core :
Depth to Top of Sample :
Depth to Bottom of Sample :

Comments : SANDS & FINES WITH PIPET METHOD. SANDS WERE SIEVED

Start Weight :　　　Final Weight : 19.044　　Deviation : %

| PHI | MM | Weight | Percent | Cumul Percent | PHI | MM | Weight | Percent | Cumul Percent |
|---|---|---|---|---|---|---|---|---|---|
| -2.25 | 4.757 | 0.000 | 0.000 | 0.000 | 3.75 | 0.074 | 1.619 | 8.501 | 35.476 |
| -2.00 | 4.000 | 0.126 | 0.662 | 0.662 | 4.00 | 0.063 | 1.207 | 6.338 | 41.814 |
| -1.75 | 3.364 | 0.015 | 0.079 | 0.740 | 4.25 | 0.053 | 0.738 | 3.875 | 45.689 |
| -1.50 | 2.828 | 0.005 | 0.026 | 0.767 | 4.50 | 0.044 | 0.738 | 3.875 | 49.564 |
| -1.25 | 2.378 | 0.016 | 0.084 | 0.851 | 4.75 | 0.037 | 1.477 | 7.756 | 57.320 |
| -1.00 | 2.000 | 0.034 | 0.179 | 1.029 | 5.00 | 0.031 | 1.477 | 7.756 | 65.076 |
| -0.75 | 1.682 | 0.013 | 0.068 | 1.097 | 5.25 | 0.026 | 0.369 | 1.938 | 67.013 |
| -0.50 | 1.414 | 0.029 | 0.152 | 1.250 | 5.50 | 0.022 | 0.369 | 1.938 | 68.951 |
| -0.25 | 1.189 | 0.004 | 0.021 | 1.271 | 5.75 | 0.019 | 0.000 | 0.000 | 68.951 |
| 0.00 | 1.000 | 0.009 | 0.047 | 1.318 | 6.00 | 0.016 | 0.000 | 0.000 | 68.951 |
| 0.25 | 0.841 | 0.002 | 0.011 | 1.329 | 6.25 | 0.013 | 0.185 | 0.971 | 69.922 |
| 0.50 | 0.707 | 0.005 | 0.026 | 1.355 | 6.50 | 0.011 | 0.185 | 0.971 | 70.894 |
| 0.75 | 0.595 | 0.004 | 0.021 | 1.376 | 6.75 | 0.009 | 0.185 | 0.971 | 71.865 |
| 1.00 | 0.500 | 0.008 | 0.042 | 1.418 | 7.00 | 0.008 | 0.185 | 0.971 | 72.837 |
| 1.25 | 0.420 | 0.009 | 0.047 | 1.465 | 7.25 | 0.007 | 0.000 | 0.000 | 72.837 |
| 1.50 | 0.354 | 0.008 | 0.042 | 1.507 | 7.50 | 0.006 | 0.000 | 0.000 | 72.837 |
| 1.75 | 0.297 | 0.020 | 0.105 | 1.612 | 7.75 | 0.005 | 0.000 | 0.000 | 72.837 |
| 2.00 | 0.250 | 0.084 | 0.441 | 2.053 | 8.00 | 0.004 | 0.000 | 0.000 | 72.837 |
| 2.25 | 0.210 | 0.191 | 1.003 | 3.056 | 8.25 | 0.003 | 0.185 | 0.971 | 73.808 |
| 2.50 | 0.177 | 0.410 | 2.153 | 5.209 | 8.50 | 0.003 | 0.185 | 0.971 | 74.779 |
| 2.75 | 0.149 | 0.664 | 3.487 | 8.696 | 8.75 | 0.002 | 0.185 | 0.971 | 75.751 |
| 3.00 | 0.125 | 0.902 | 4.736 | 13.432 | 9.00 | 0.002 | 0.185 | 0.971 | 76.722 |
| 3.25 | 0.105 | 1.624 | 8.528 | 21.960 | 9.25 | 0.002 | 4.433 | 23.278 | 100.000 |
| 3.50 | 0.088 | 0.955 | 5.015 | 26.974 | | | | | |

Sample Content by Weight Percent :

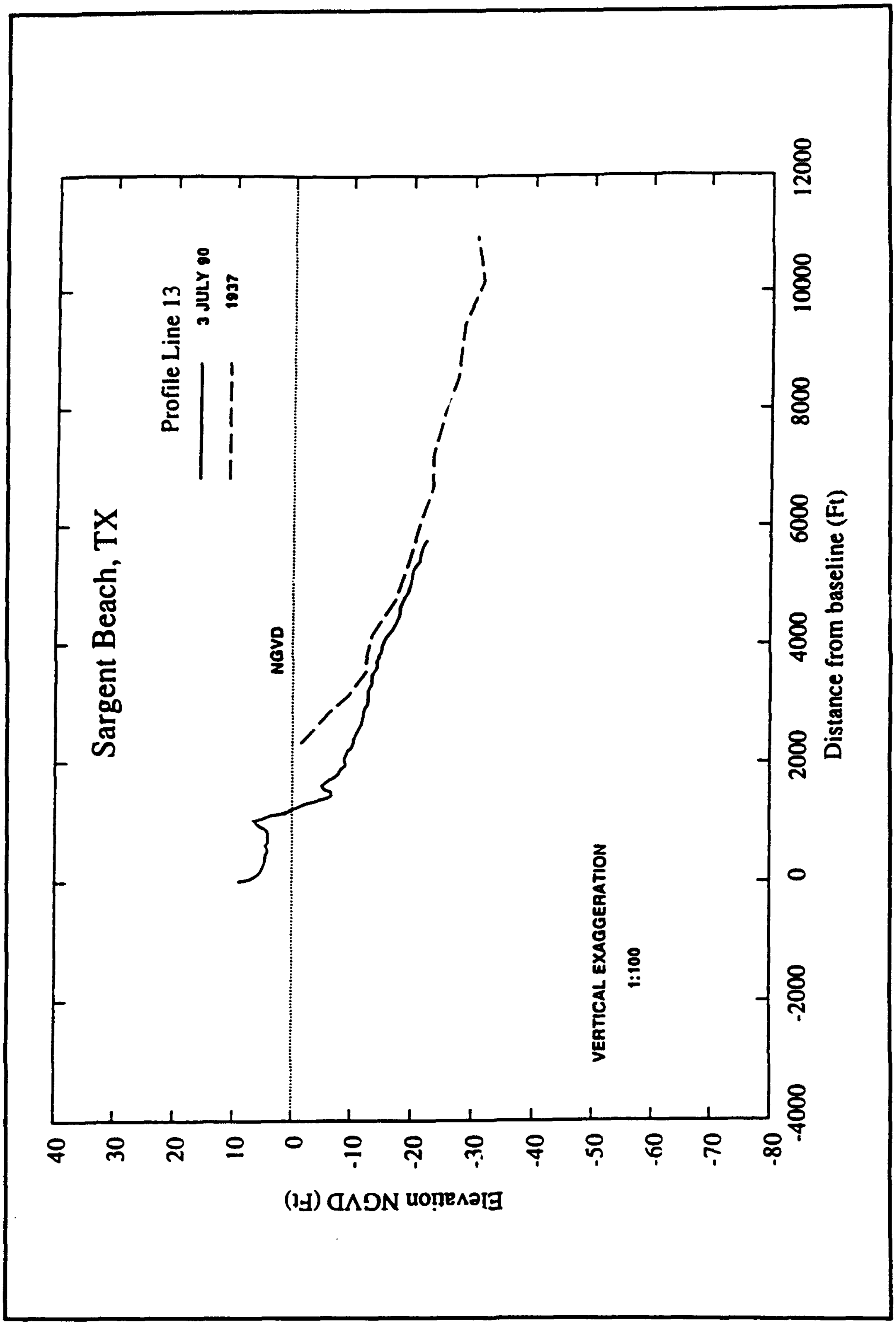
| | Gravel | Sand coarse | Sand medium | Sand fine | Silt | Clay |
|---|---|---|---|---|---|---|
| Wentworth Classification | 1.029 | 0.389 | 0.635 | 39.761 | 31.023 | 27.160 |
| Unified Classification | 0.000 | 1.029 | 0.436 | 34.011 | 37.361 | 27.160 |

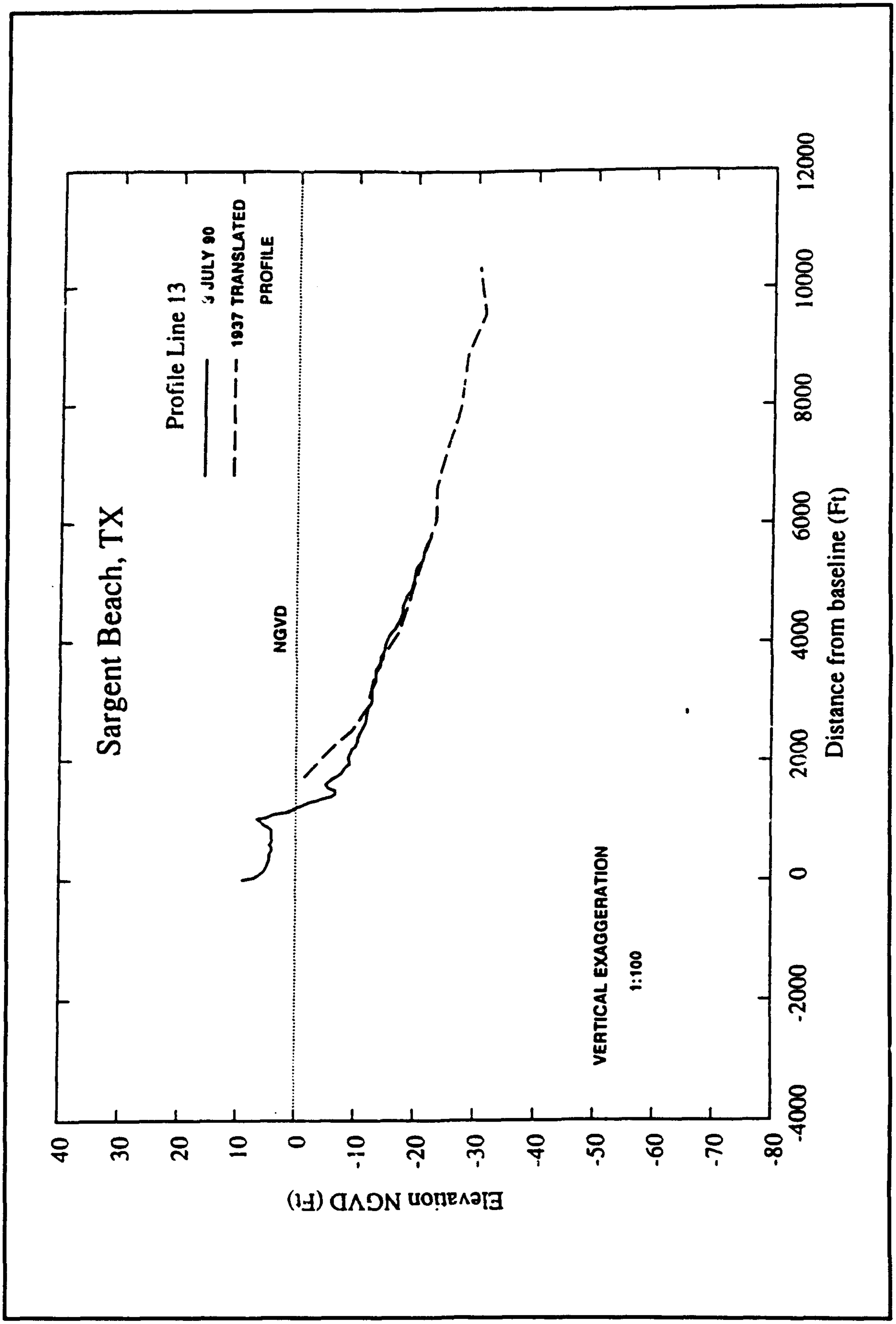
Standard Statistics :

| | Median | Mean | Dev. | Skew | Kurt |
|---|---|---|---|---|---|
| Method of Moments (PHI) | | 5.26 | 2.55 | 0.38 | 2.30 |
| Folk Graphic Measures (PHI) | 4.51 | 5.56 | 2.52 | 0.46 | 0.53 |
| Grain Size (mm) | 0.04 | 0.03 | | | |

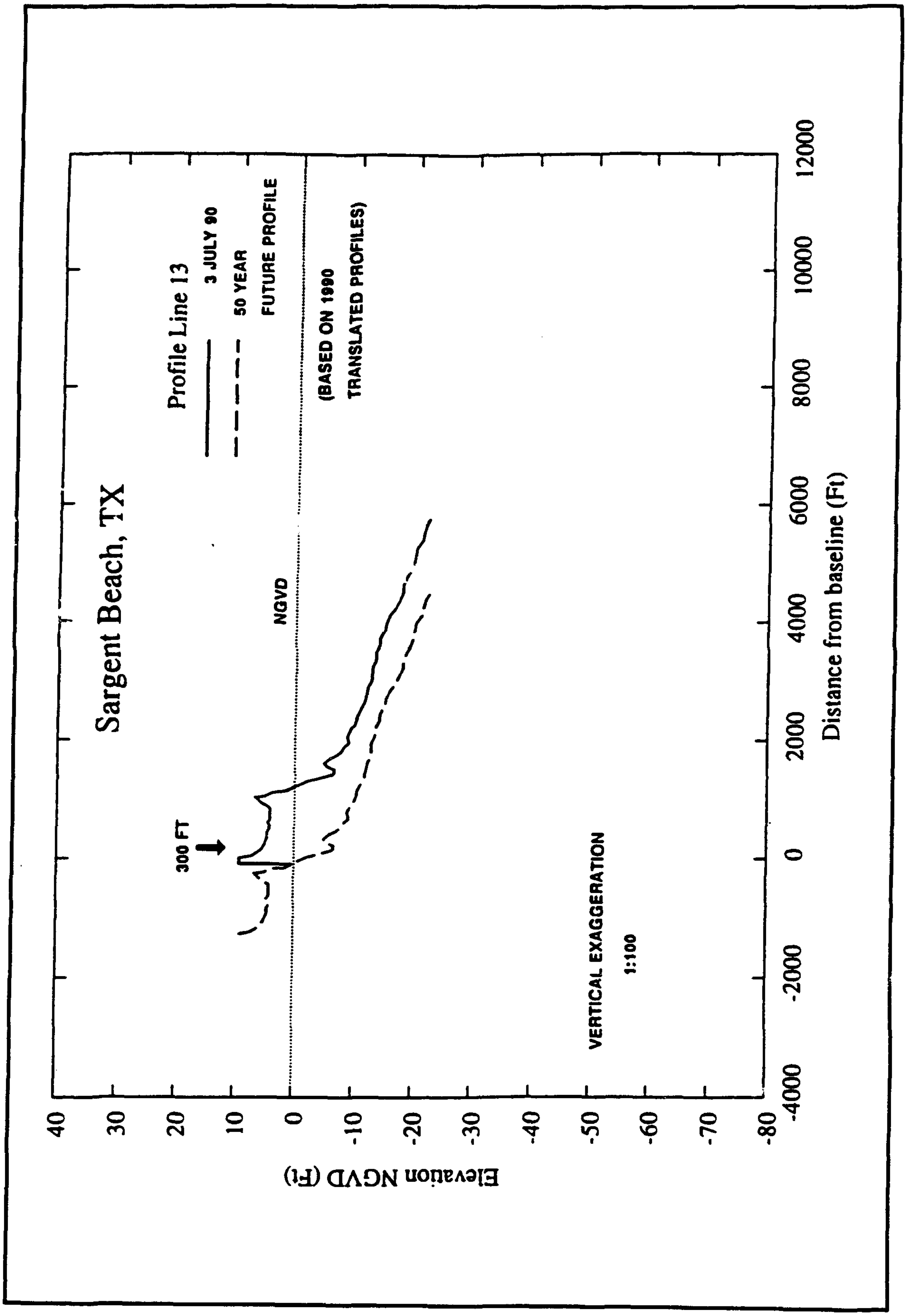
# Appendix C Comparison of 1937 and 1990 Profiles

Appendix C consists of profile position comparisons in various locations of the study area. The profile sites encompass S-13 southwest of McCabe's Cut, S-20 northeast of Charpiot's Cut, S-24 between Charpiot's Cut and Cedar Lakes, and S-28 near Cedar Lake. Comparison profile plots of 1937 and 1990, 1990 and a 1937 matched slope translation to 1990, 1990 and a projected future 1990 profile translated landward when the shoreline at the present rate of retreat (approximately 30 ft/yr) intersects the GIWW (Gulf Intracoastal Waterway) shoreline, and 1990 with a 50 year future profile translated from the 1990 profile based on the present rate of retreat are illustrated. A 300 ft mark is placed on the last two scenarios to indicate the desired width to maintian a barrier 300 ft seaward of the GIWW.


Sargent Beach, TX
Profile Line 13
3 JULY 90
1937
NGVD
VERTICAL EXAGGERATION
1:100
Elevation NGVD (Ft)
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-4000
-2000
0
2000
4000
6000
8000
10000
12000
Distance from baseline (Ft)



Sargent Beach, TX
Profile Line 13
JULY 90
1937 TRANSLATED PROFILE
NGVD
VERTICAL EXAGGERATION
1:100
Elevation NGVD (Ft)
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-4000
-2000
0
2000
4000
6000
8000
10000
12000
Distance from baseline (Ft)


Sargent Beach, TX
Profile Line 13
3 JULY 90
50 YEAR
FUTURE PROFILE
(BASED ON 1990
TRANSLATED PROFILES)
NGVD
300 FT
VERTICAL EXAGGERATION
1:100
Elevation NGVD (Ft)
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
Distance from baseline (Ft)
-4000
-2000
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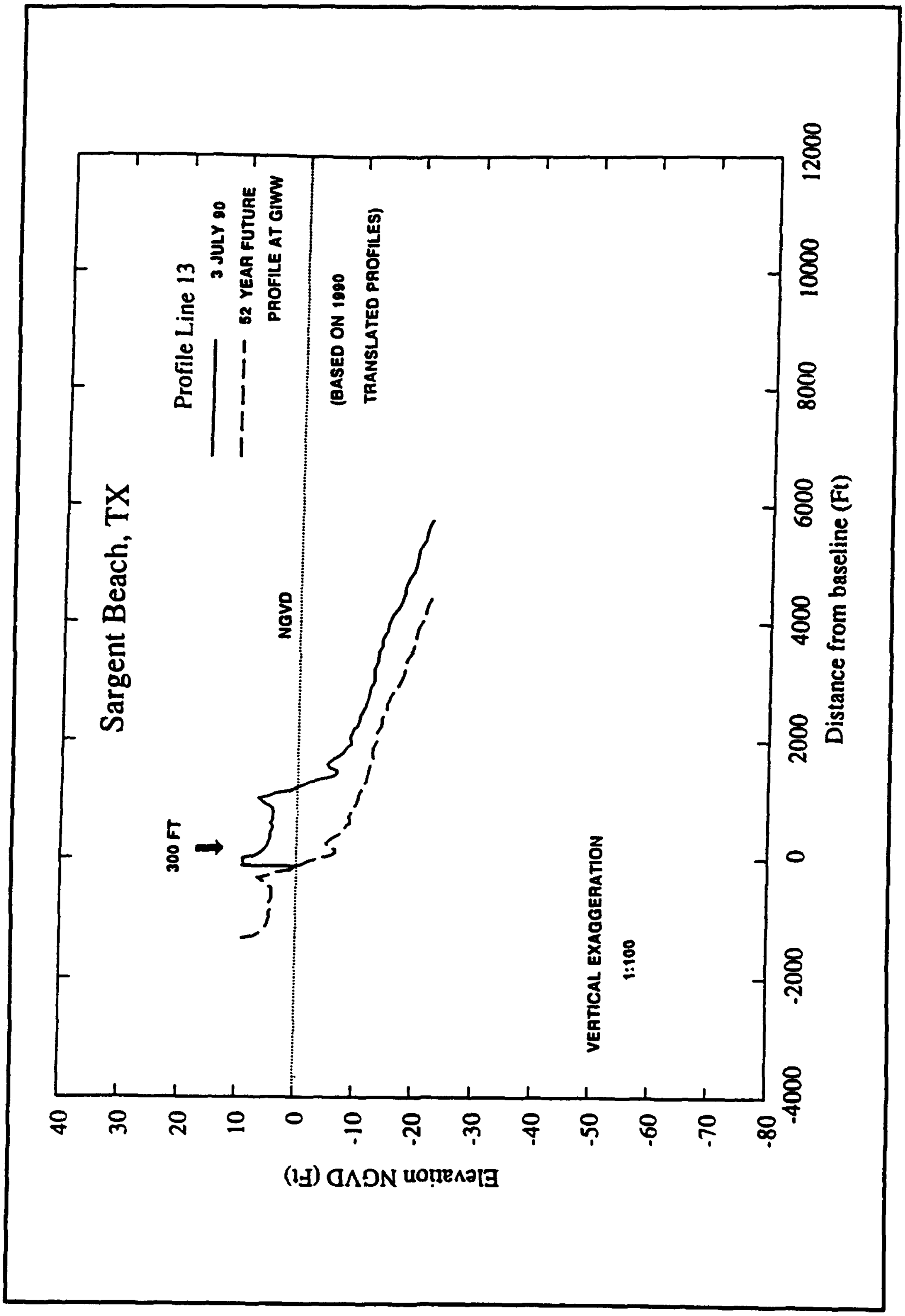
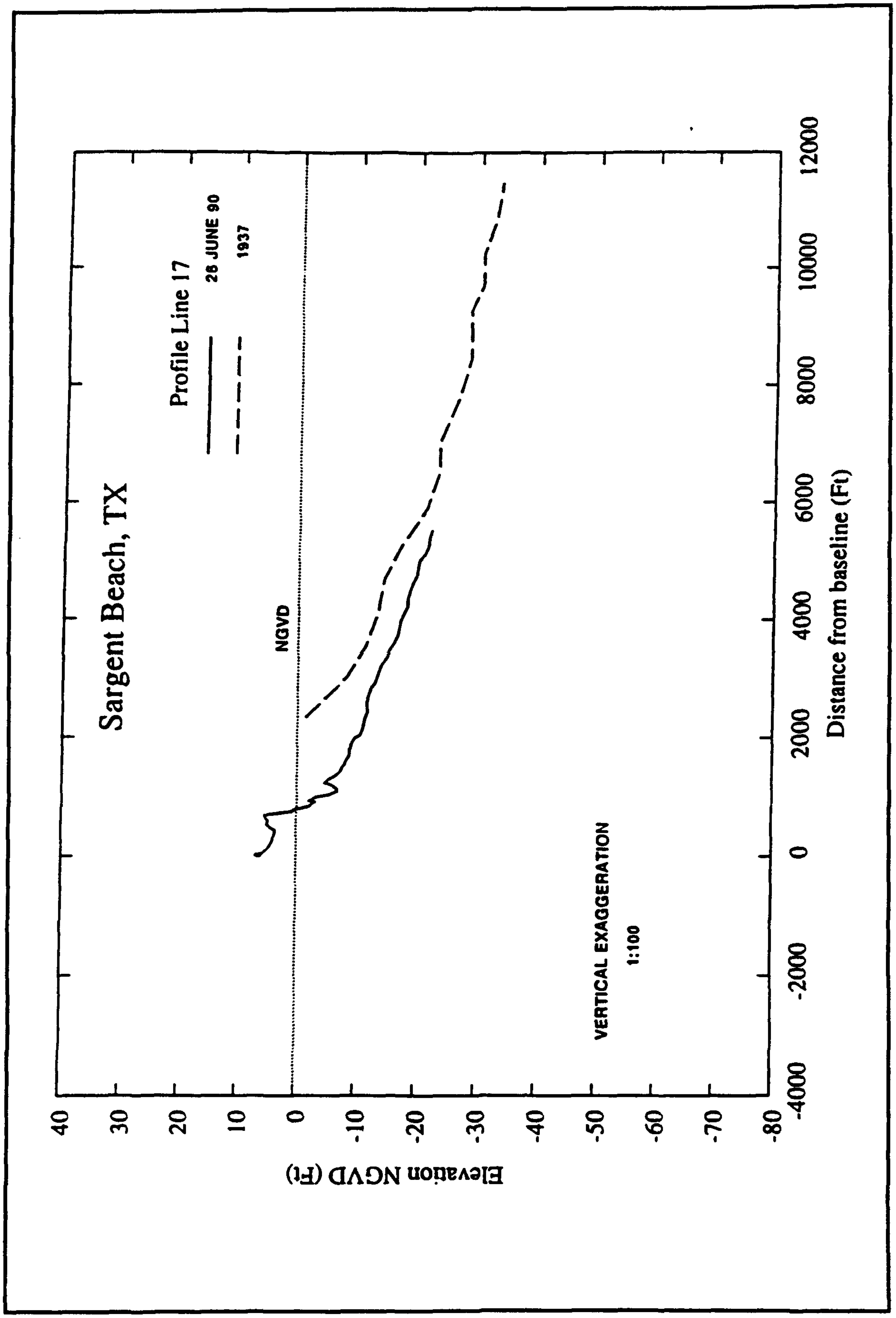
2000
4000
6000
8000
10000
12000


Sargent Beach, TX
Profile Line 13
3 JULY 90
52 YEAR FUTURE PROFILE AT GIWW
(BASED ON 1990 TRANSLATED PROFILES)
NGVD
300 FT
VERTICAL EXAGGERATION
1:100
Elevation NGVD (Ft)
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-4000
-2000
0
2000
4000
6000
8000
10000
12000
Distance from baseline (Ft)


Sargent Beach, TX
Profile Line 17
28 JUNE 90
1937
NGVD
VERTICAL EXAGGERATION
1:100
Elevation NGVD (Ft)
40
30
20
10
0
-10
-20
-30
-40
-50
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-70
-80
Distance from baseline (Ft)
-4000
-2000
0
2000
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6000
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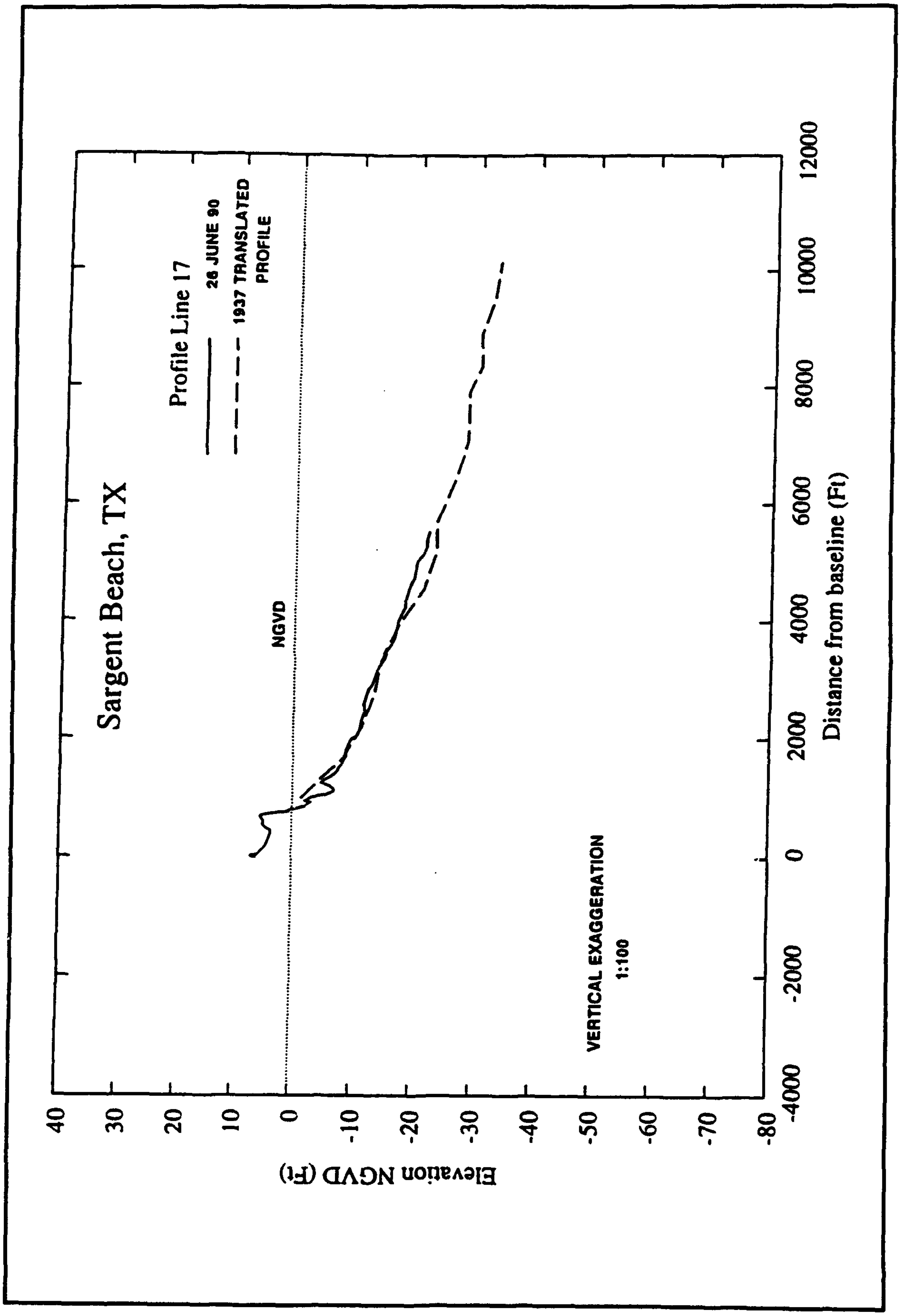
12000


Sargent Beach, TX
Profile Line 17
26 JUNE 90
1937 TRANSLATED PROFILE
NGVD
VERTICAL EXAGGERATION 1:100
Elevation NGVD (Ft)
Distance from baseline (Ft)
40
30
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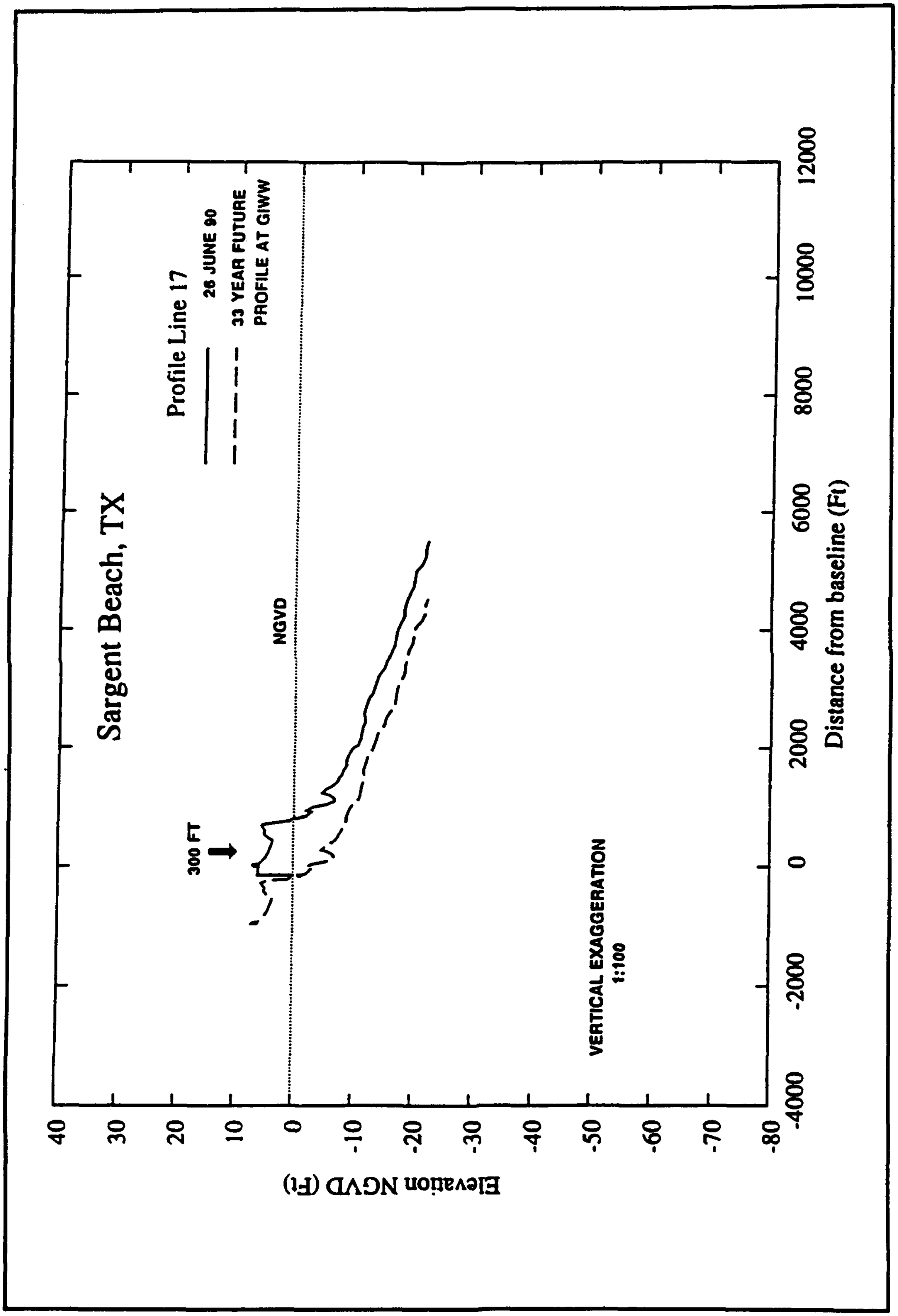
Sargent Beach, TX
Profile Line 17
26 JUNE 90
33 YEAR FUTURE
PROFILE AT GIWW
NGVD
300 FT
VERTICAL EXAGGERATION
1:100
Elevation NGVD (Ft)
Distance from baseline (Ft)
40
30
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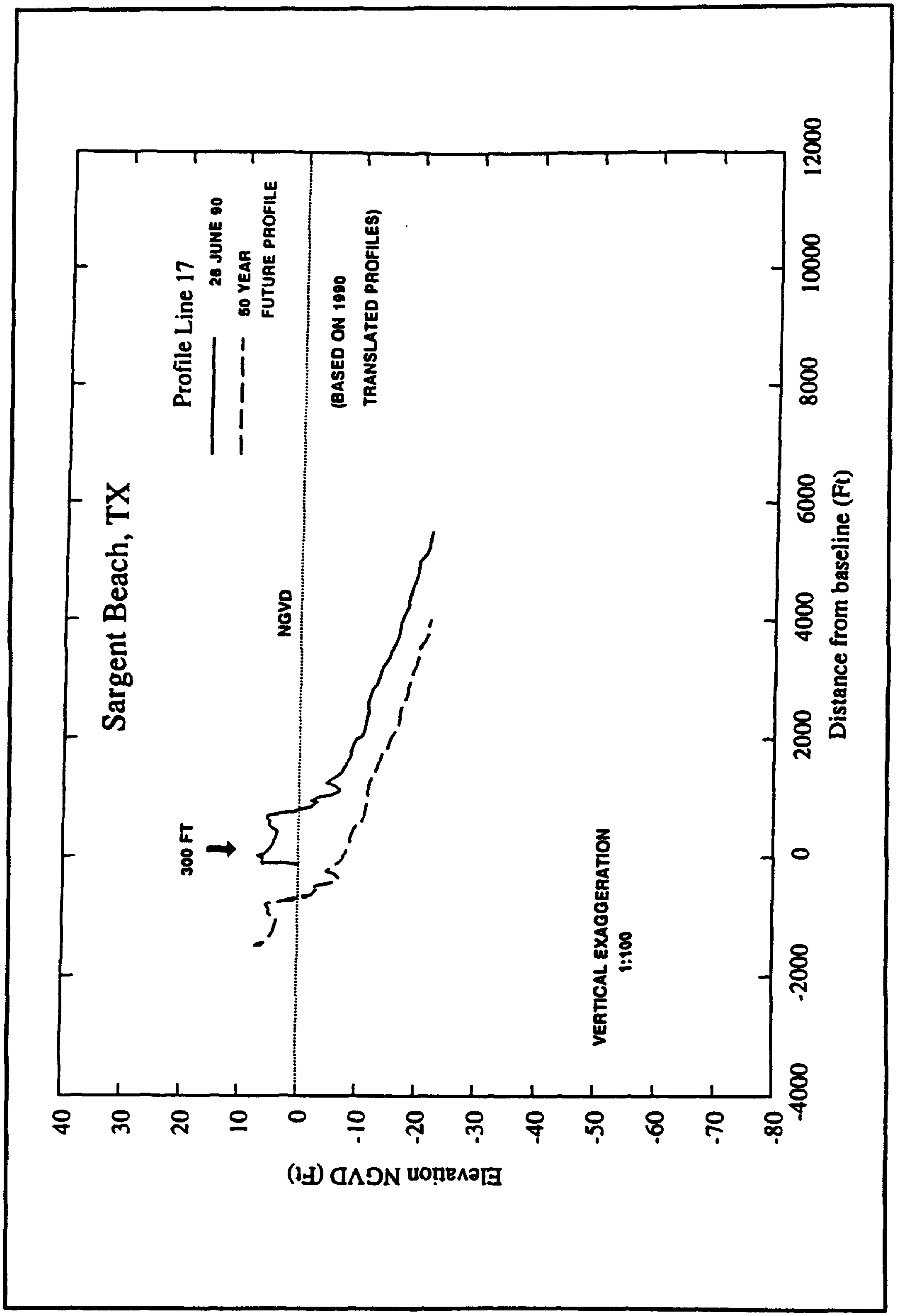
Sargent Beach, TX
Profile Line 17
26 JUNE 90
50 YEAR
FUTURE PROFILE
(BASED ON 1990
TRANSLATED PROFILES)
300 FT
NGVD
VERTICAL EXAGGERATION
1:100
Elevation NGVD (Ft)
Distance from baseline (Ft)
40
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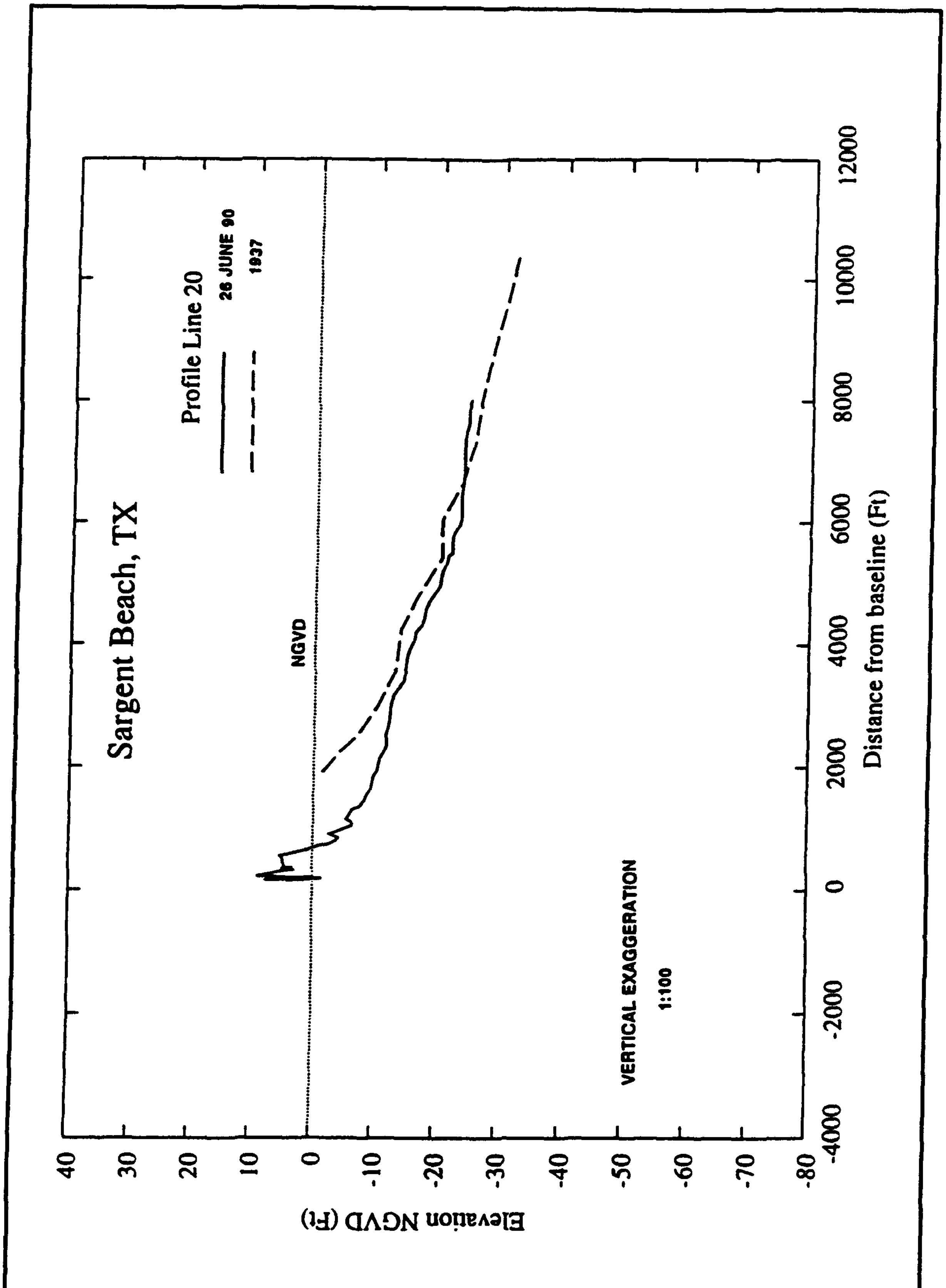
Sargent Beach, TX
Profile Line 20
26 JUNE 90
1937
NGVD
VERTICAL EXAGGERATION
1:100
Elevation NGVD (Ft)
40
30
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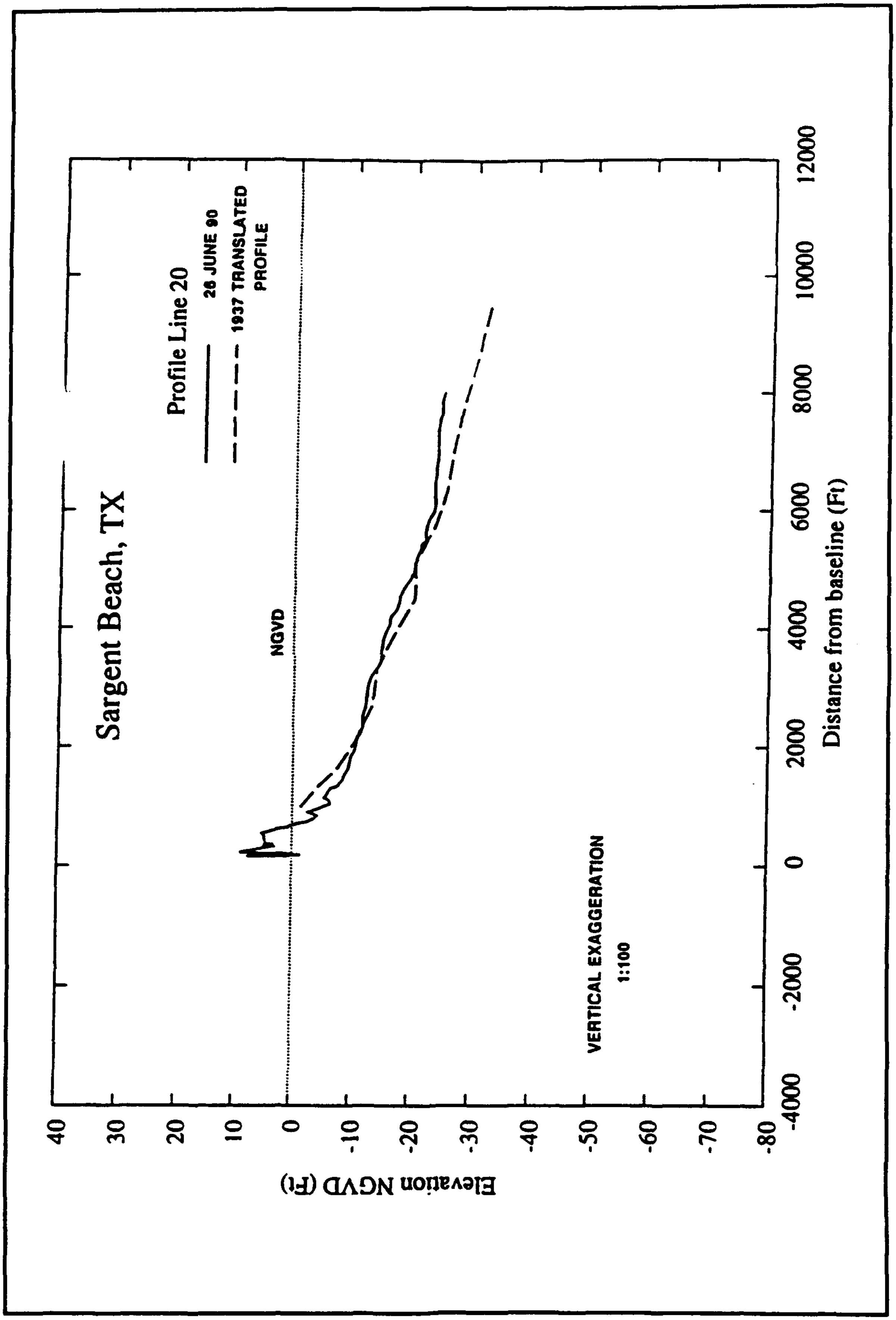
Distance from baseline (Ft)


Sargent Beach, TX
Profile Line 20
26 JUNE 90
1937 TRANSLATED PROFILE
NGVD
VERTICAL EXAGGERATION
1:100
Elevation NGVD (Ft)
40
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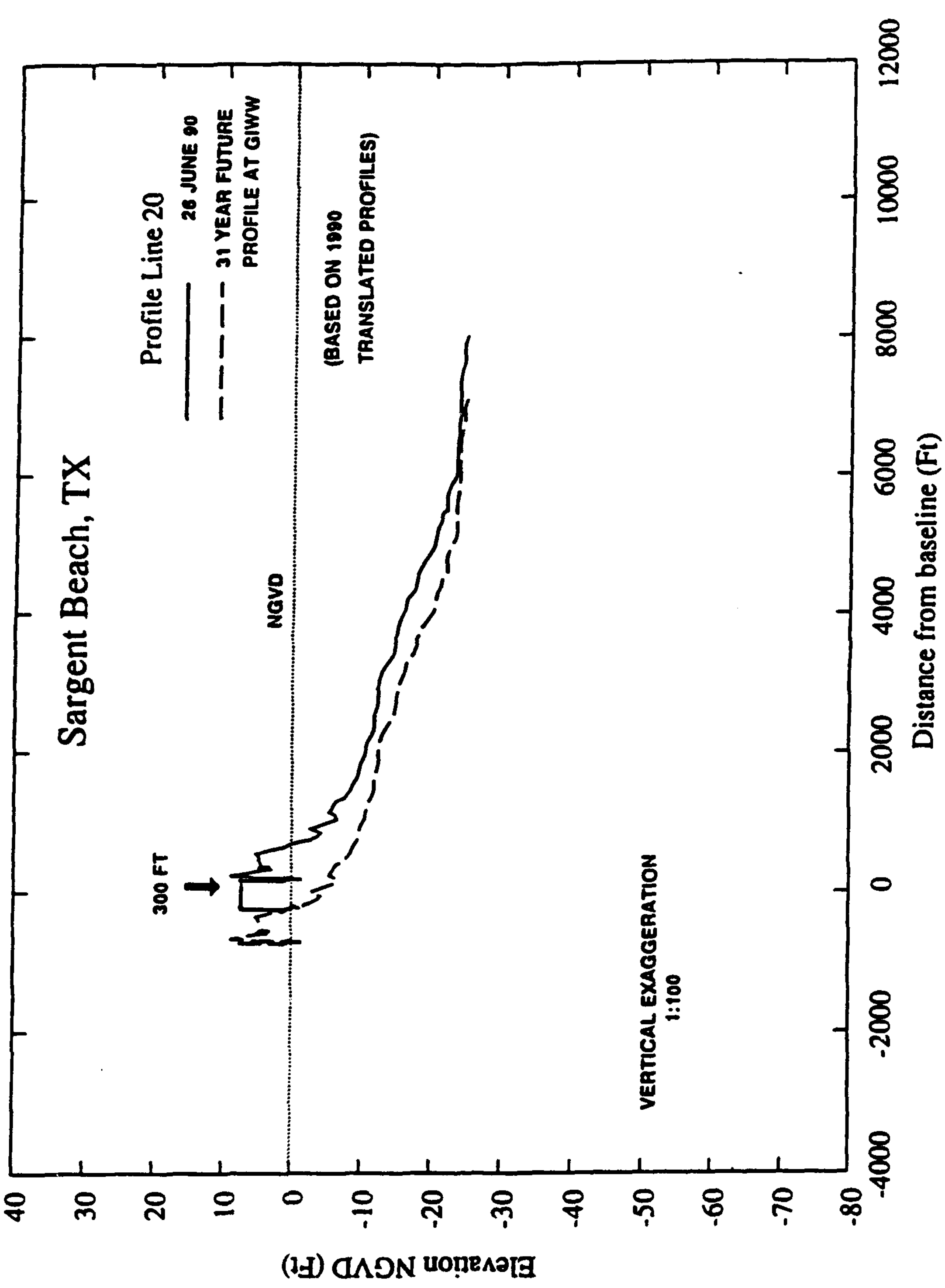
12000
Distance from baseline (Ft)


Sargent Beach, TX
Profile Line 20
26 JUNE 90
31 YEAR FUTURE PROFILE AT GIWW
(BASED ON 1990 TRANSLATED PROFILES)
NGVD
300 FT
VERTICAL EXAGGERATION 1:100
Elevation NGVD (Ft)
Distance from baseline (Ft)
40
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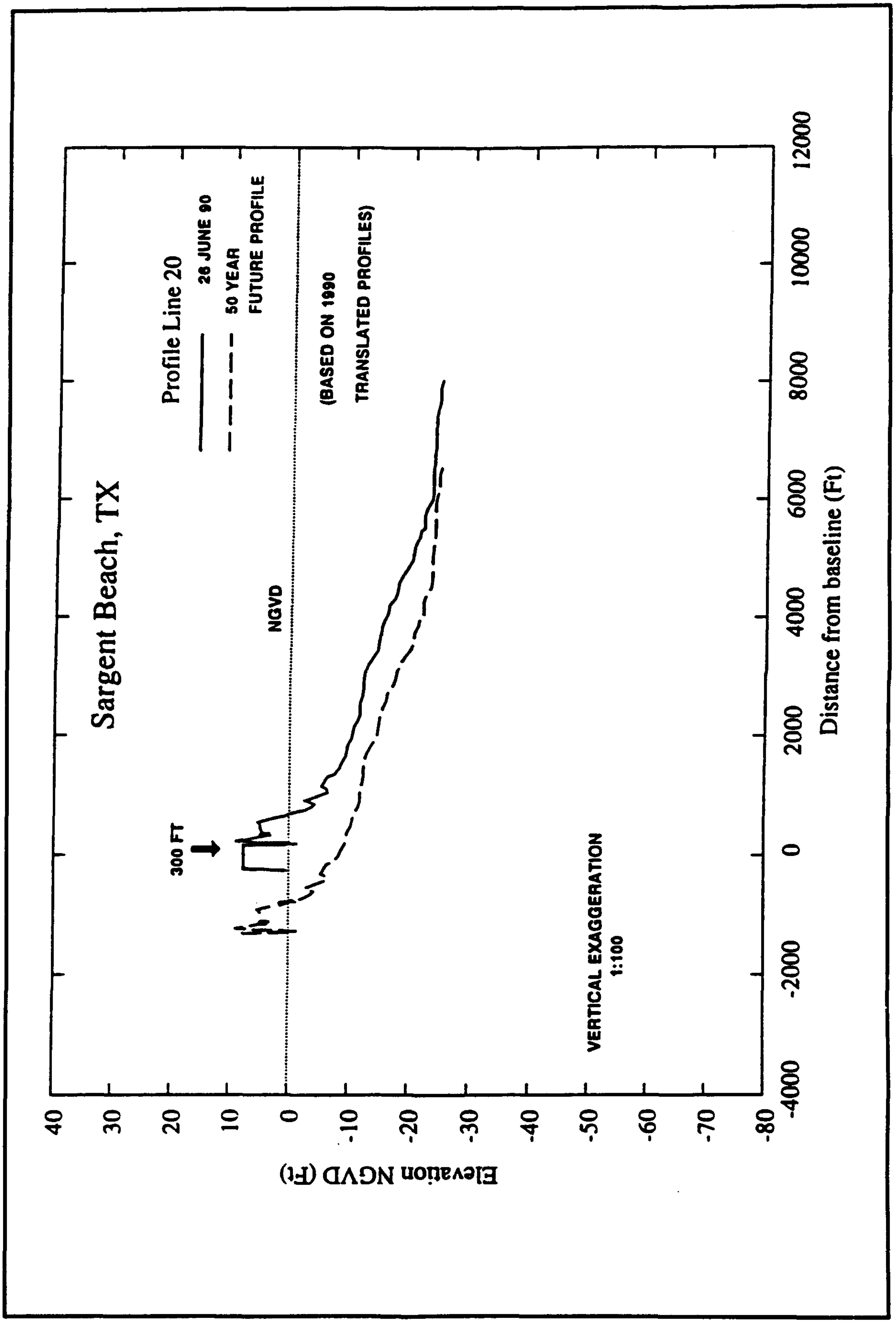

Sargent Beach, TX
Profile Line 20
26 JUNE 90
50 YEAR
FUTURE PROFILE
(BASED ON 1990
TRANSLATED PROFILES)
NGVD
300 FT
VERTICAL EXAGGERATION
1:100
Elevation NGVD (Ft)
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Distance from baseline (Ft)
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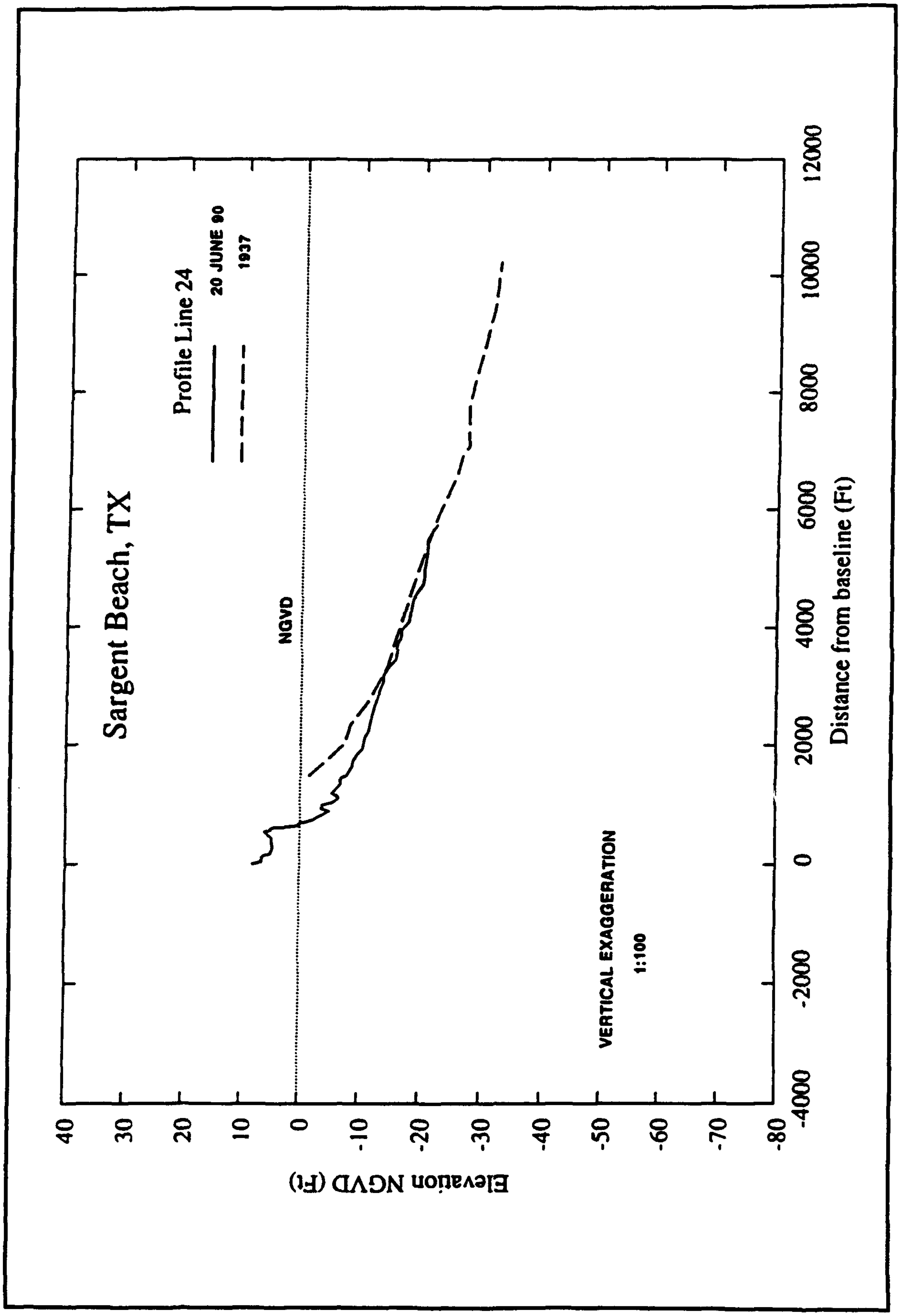

Sargent Beach, TX
Profile Line 24
20 JUNE 90
1937
NGVD
VERTICAL EXAGGERATION
1:100
Elevation NGVD (Ft)
Distance from baseline (Ft)
40
30
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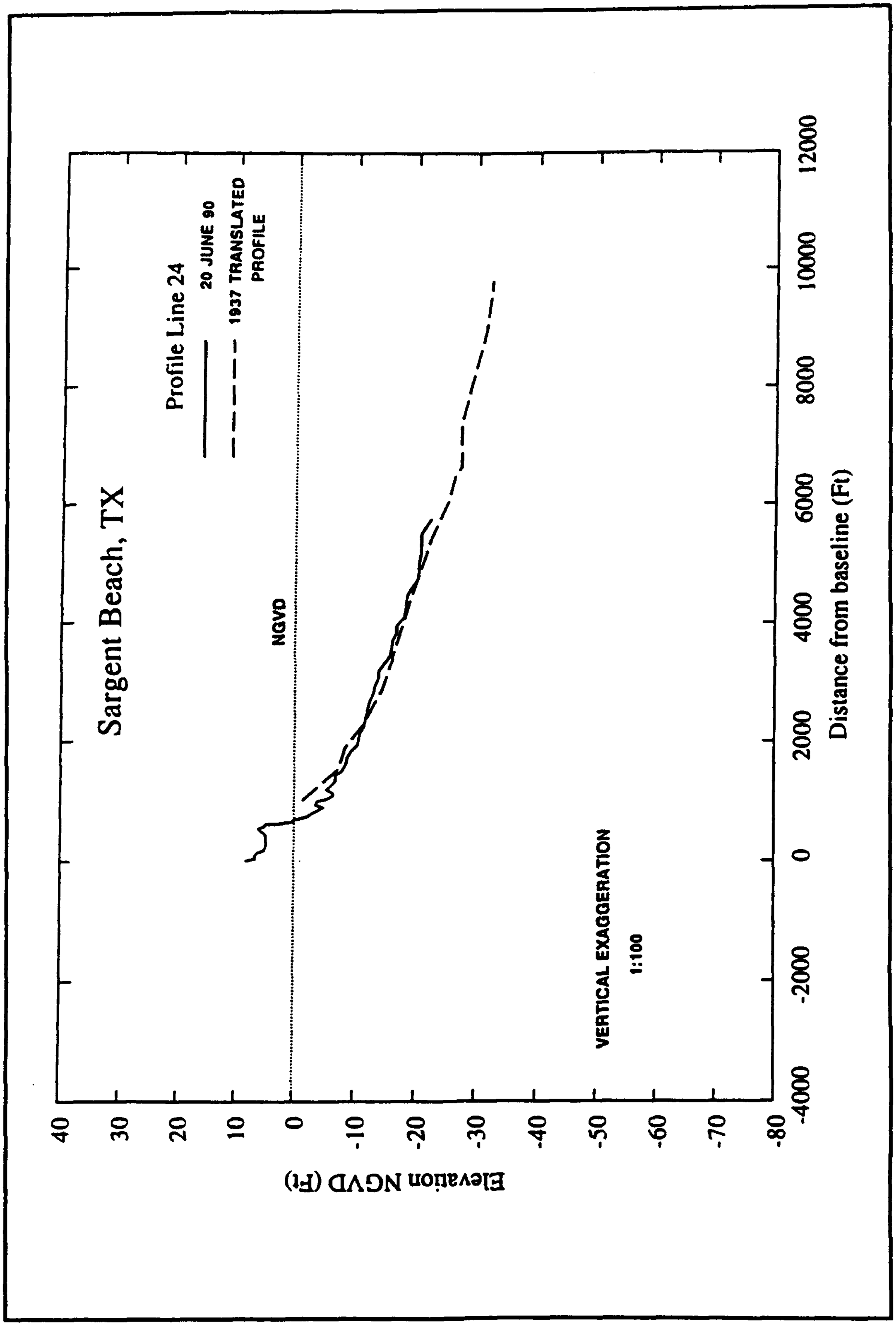

Sargent Beach, TX
Profile Line 24
20 JUNE 90
1937 TRANSLATED PROFILE
NGVD
VERTICAL EXAGGERATION
1:100
40
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-10
-20
-30
-40
-50
-60
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-80
Elevation NGVD (Ft)
-4000
-2000
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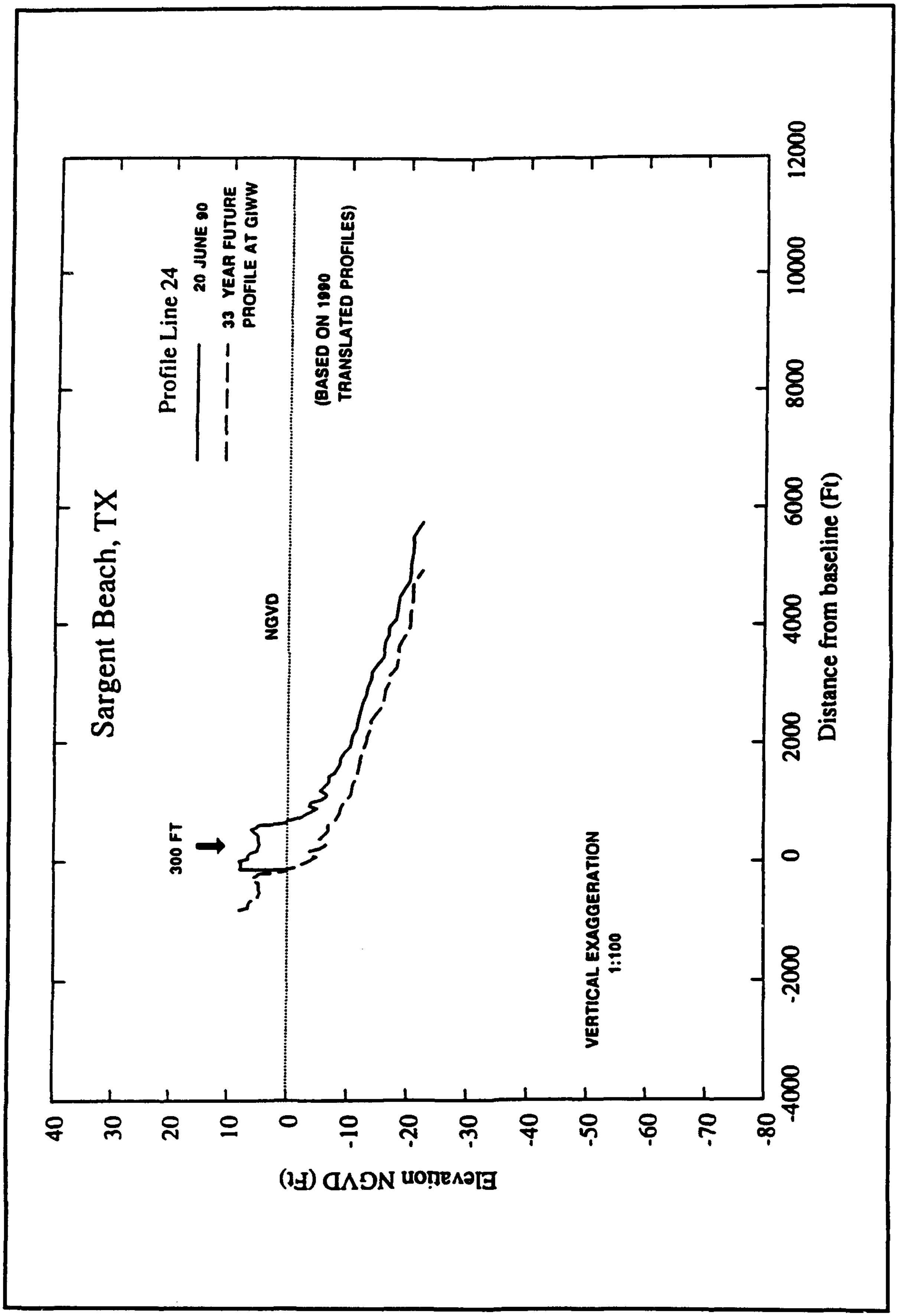
6000
8000
10000
12000
Distance from baseline (Ft)



Sargent Beach, TX
Profile Line 24
20 JUNE 90
33 YEAR FUTURE PROFILE AT GIWW
(BASED ON 1990 TRANSLATED PROFILES)
300 FT
NGVD
VERTICAL EXAGGERATION 1:100
Elevation NGVD (Ft)
Distance from baseline (Ft)
40
30
20
10
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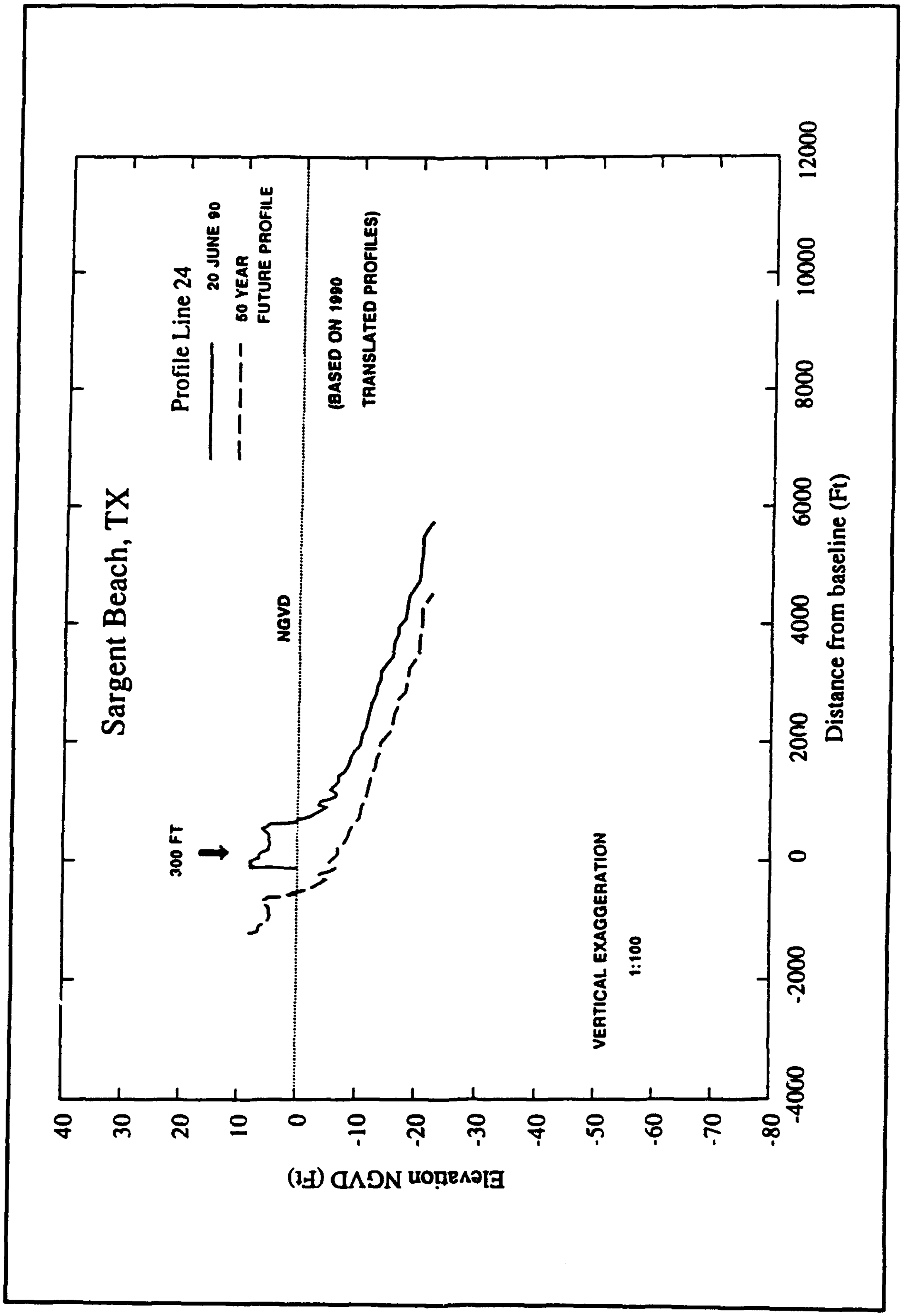
Sargent Beach, TX
Profile Line 24
20 JUNE 90
50 YEAR FUTURE PROFILE
(BASED ON 1990 TRANSLATED PROFILES)
NGVD
300 FT
VERTICAL EXAGGERATION
1:100
40
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Elevation NGVD (Ft)
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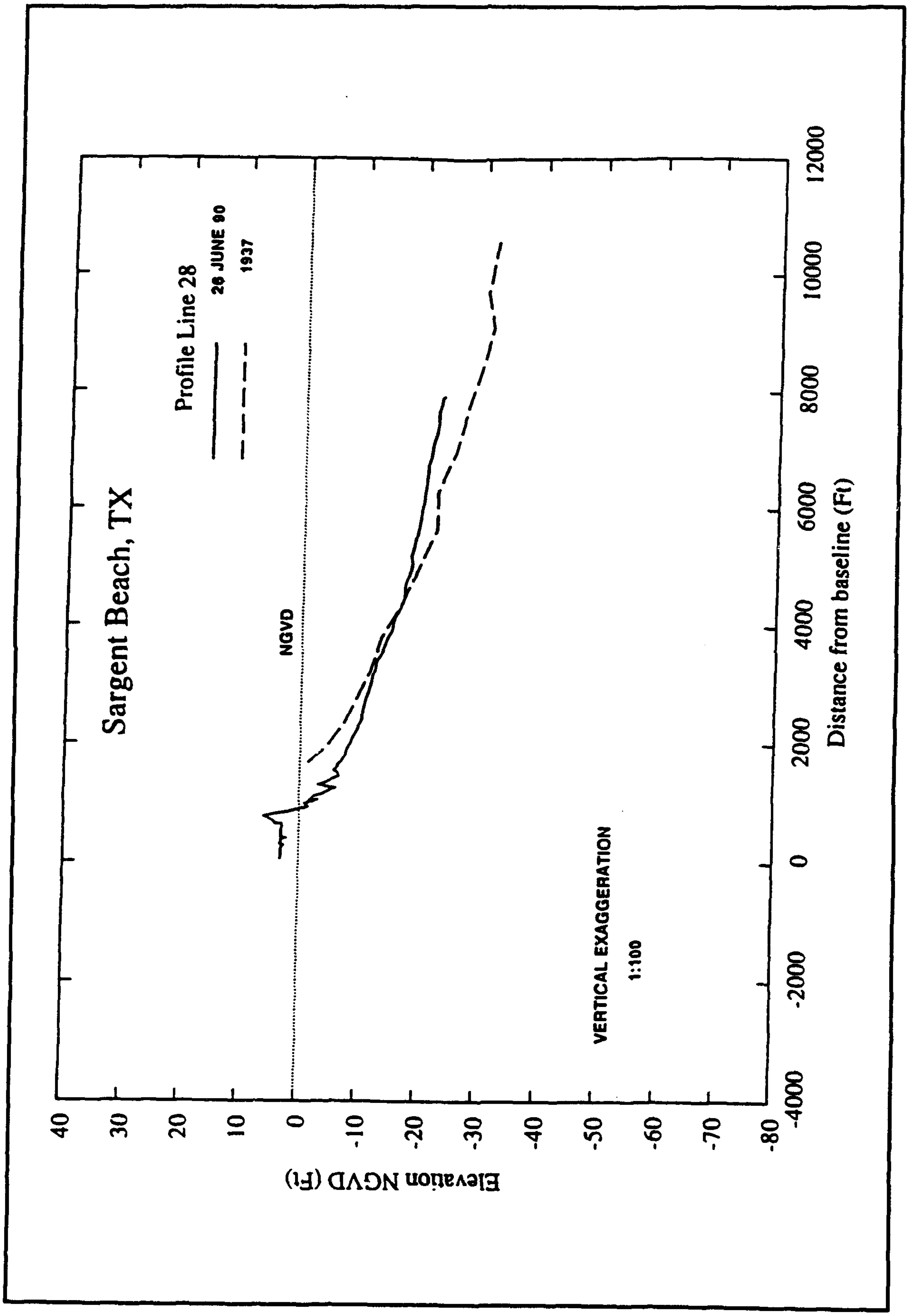
12000
Distance from baseline (Ft)



Sargent Beach, TX
Profile Line 28
28 JUNE 90
1937
NGVD
VERTICAL EXAGGERATION
1:100
Elevation NGVD (Ft)
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-4000
-2000
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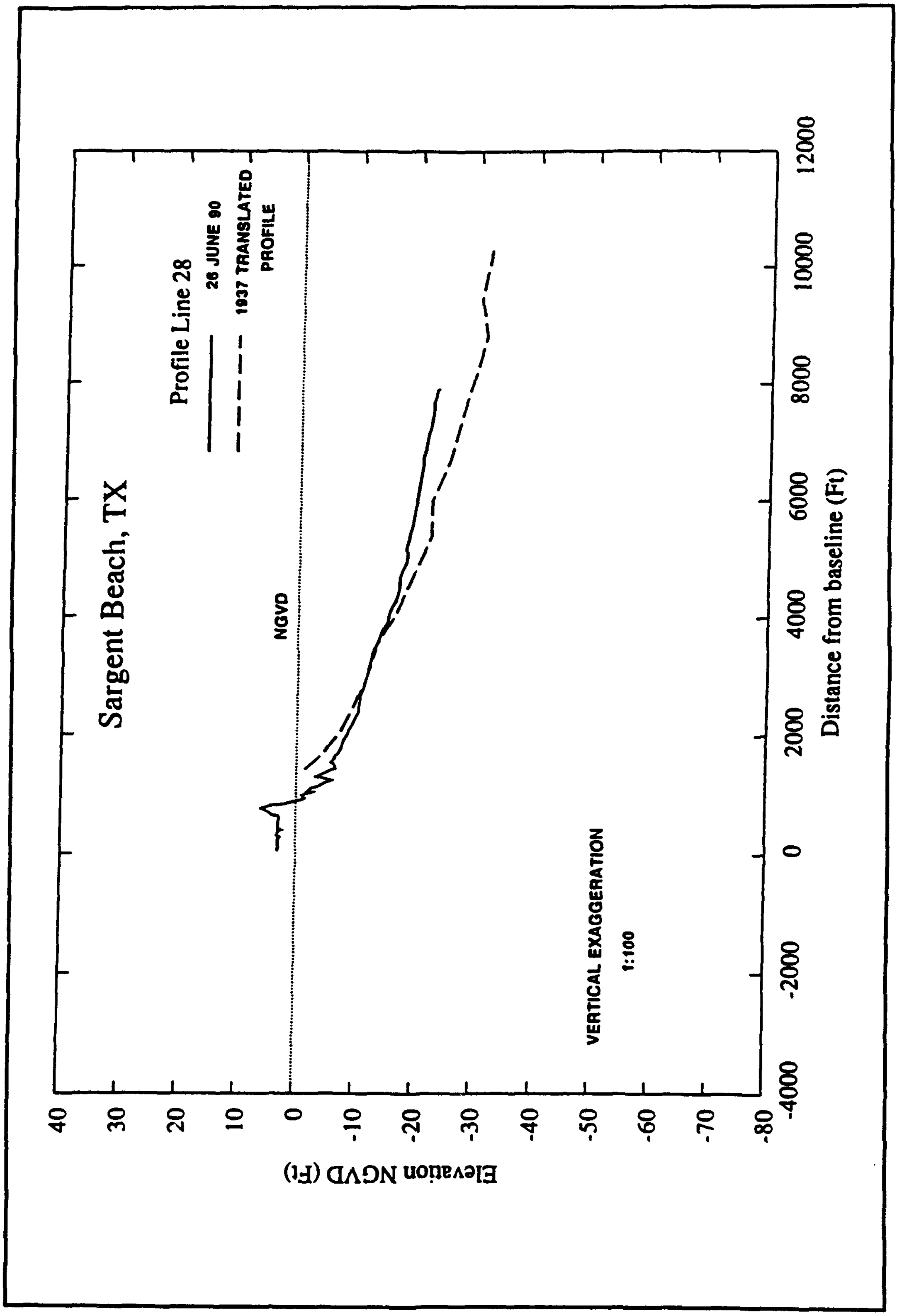
10000
12000
Distance from baseline (Ft)


Sargent Beach, TX
Profile Line 28
26 JUNE 90
1937 TRANSLATED PROFILE
NGVD
VERTICAL EXAGGERATION
1:100
Elevation NGVD (Ft)
Distance from baseline (Ft)
40
30
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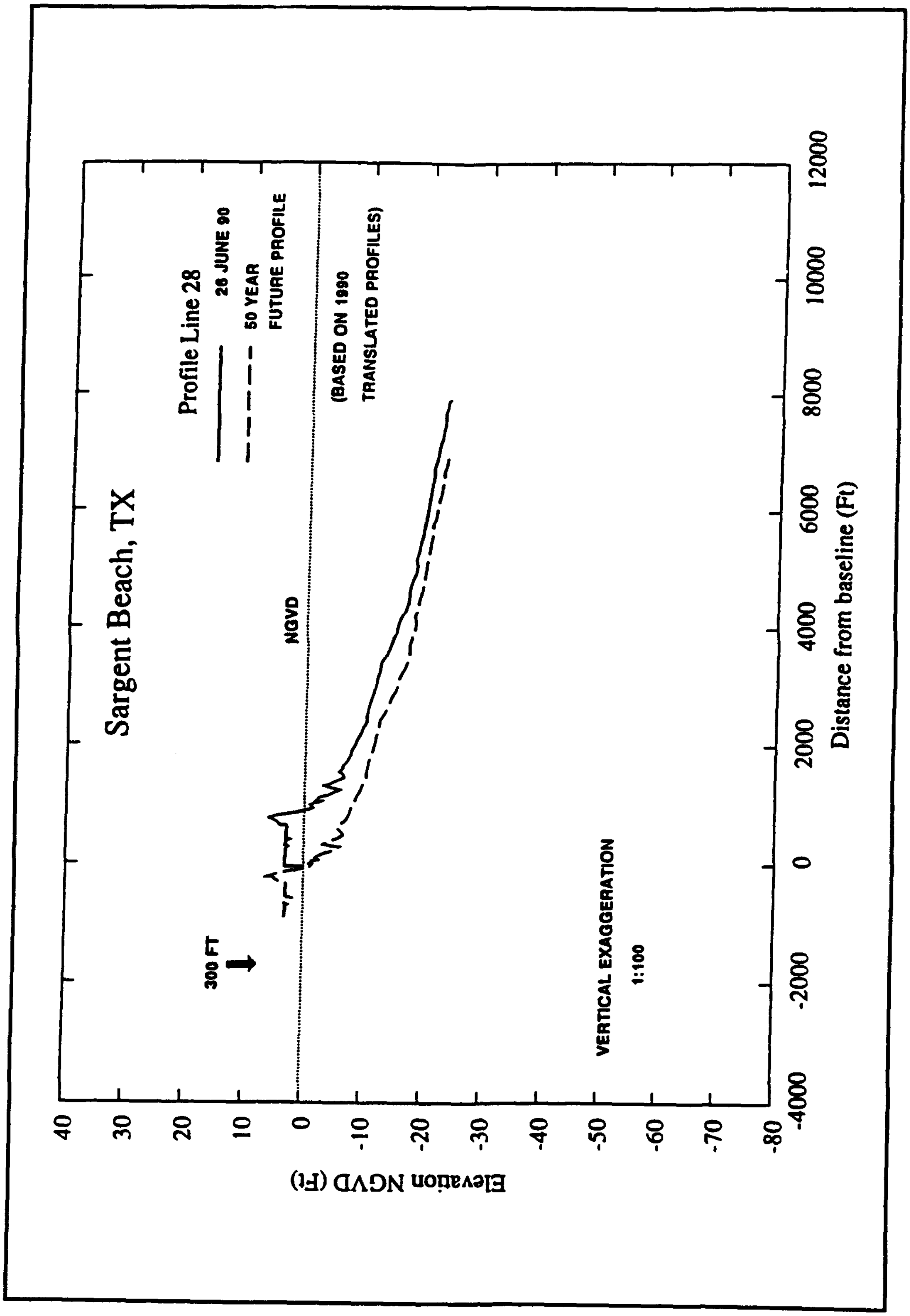
Sargent Beach, TX
Profile Line 28
26 JUNE 90
50 YEAR FUTURE PROFILE
(BASED ON 1990 TRANSLATED PROFILES)
NGVD
300 FT
VERTICAL EXAGGERATION
1:100
Elevation NGVD (Ft)
Distance from baseline (Ft)
40
30
20
10
0
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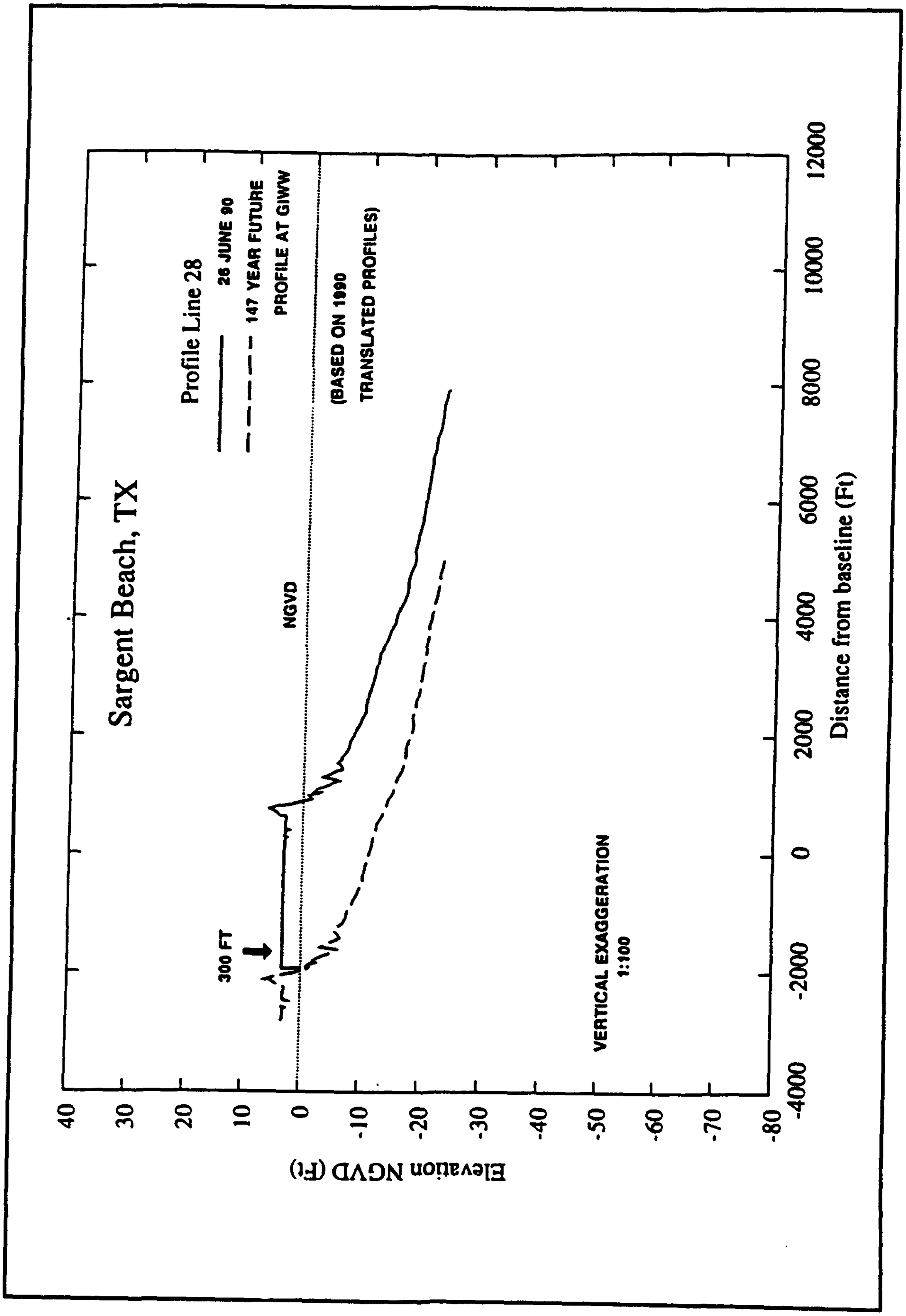

Sargent Beach, TX
Profile Line 28
26 JUNE 90
147 YEAR FUTURE PROFILE AT GIWW
(BASED ON 1990 TRANSLATED PROFILES)
NGVD
300 FT
VERTICAL EXAGGERATION 1:100
Elevation NGVD (Ft)
Distance from baseline (Ft)
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-4000
-2000
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2000
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6000
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10000
12000

# REPORT DOCUMENTATION PAGE

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Donald K. Stauble, Jon M. Hubertz, Robin J. Hoban, Claire R. Livingston, Cheryl E. Pollock, Douglas R. Levin

**7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)**
U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199,
Bryant College, 1150 Douglas Pike, Smithfield, RI 02917

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Galveston, TX 77550

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**11. SUPPLEMENTARY NOTES**
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Approved for public release; distribution is unlimited.

**12b. DISTRIBUTION CODE**

**13. ABSTRACT** *(Maximum 200 words)*

One of the areas of highest coastal erosion along the Texas coast is located in the deltaic headland coastal segment of the Brazos River in the vicinity of Sargent Beach. Because of this erosion, a section of the Gulf Intracoastal Waterway (GIWW) from Cedar Lakes to East Matagorda Bay is in danger of intrusion from breaching of the narrow (less than 300-m-wide) shorefront. Owing to its deltaic origin, the beach is composed of cohesive fine-grained clay and silt material, overlain by a narrow layer of coastal peat and topped by a thin veneer of fine-grained quartz beach sand with a high percentage of shell fragments. Within the 24-year study period (1965-1989), the northeastern half of the study area measured an average erosion rate of 25 ft/yr (7.6 m/yr) and consisted of a thin sandy flat sloping beach over the clay deposit. The southwestern section has up to 1-m-high clay bluffs outcropping into the surf zone and measured an average 36 ft/yr (11 m/yr) erosion rate. It is speculated that this high erosion rate is a result of intermittent wave cutting of large chunks of the clay bluff material. The overall erosion rate along this coast is due to a general lack of sand.

To aid in design of shoreline protection for this coast, an historical analysis of hurricanes was completed. Seventeen hurricanes that made landfall within 75 n.m. of Sargent Beach were category 1 storms, with one each of categories 2 and 4, and five of category 3. Based on historical storm analysis, water levels for Sargent Beach totalling from 4-6 ft would have a return

(Continued)

**14. SUBJECT TERMS**
Beach nourishment assessment
Cohesive shoreline erosion mechanism
Historical hurricanes
Hurricane water levels
Sediment distribution
Shoreline change analysis
Texas Coast
Wave height estimation

**15. NUMBER OF PAGES**
153

**16. PRICE CODE**

| 17. SECURITY CLASSIFICATION OF REPORT | 18. SECURITY CLASSIFICATION OF THIS PAGE | 19. SECURITY CLASSIFICATION OF ABSTRACT | 20. LIMITATION OF ABSTRACT |
|---|---|---|---|
| UNCLASSIFIED | UNCLASSIFIED | | |

**13. (Concluded).**

period of around 7 years, 6- to 8-ft waves would have a return period of 14 years, 8- to 12-ft waves would have a return period of 24 years, and the return period for 14- to 16- ft waves would be 53 years. Wave heights at the shoreline were estimated to be 3-5 ft for a return period of 7 years, 5-6.5 ft for 14 years, 6.5-9.5 ft for 24 years, and 11-13 ft for 53 years.

Design of a beach nourishment option to protect the GIWW at Sargent Beach presents a unique challenge because of the deltaic mud headland sediment that exists there, with its thin veneer of sand over mud, and the mud cliff erosion mechanism. Minimal design guidance and historical precedence are available for this type of coastal environment. A suficient volume of suitable sand fill material, necessary for the required storm protection, may be lacking due to limited local borrow areas.